JPRS-USP-89-004
16 FEBRUARY 1989

FOREIGN BROADCAST INFORMATION SERVICE

JPRS Report

Science & Technology

USSR: Space

Science & Technology
USSR: Space

JPRS-USP-89-004 16 February 1989

CONTENTS

Interplanetary Sciences

Life Sciences

Interview with Col. Gen. Avn. Titov on Energiya Booster

18660001 Moscow KRASNAYA ZVEZDA in Russian
17 Aug 88 pp 1-2

[Article by Col. M. Rebrov, who interviewed Col. Gen. of Aviation G. T. Titov: "The Energiya Rocket—A Formula for Space Acceleration"; the first two paragraphs appeared in boldface italic in source]

[Text] **Space systems of various kind have become a firm fixture of our daily life. As already reported, design-flight testing of the powerful new booster rocket Energiya has begun and a project is under way for a Soviet reusable spacecraft. In letters to the editor, many of our readers express interest in these projects, the specifications of the new systems, and their prospective applications.**

We asked Col. Gen. of Aviation German Stepanovich Titov, USSR pilot-cosmonaut and Hero of the Soviet Union, to respond to these and other questions.

[Question]: The term "industrial development of space" is being used with increasing currency. What does this mean?

[Answer]: First of all, carrying out comprehensive basic scientific research in outer space, further improvement and extensive use of satellite information systems in behalf of science and the economy, the development of space technology, materials science and machine building, and the creation of large manned and unmanned orbital complexes. In the more distant future, there may be space-based power stations utilizing solar or nuclear energy in orbit around the earth, and ecologically harmful industries which pollute the environment may be moved outside the atmosphere. Perhaps, as time passes, industrial exploitation of the raw materials of the moon may begin, and expeditions might be sent to the planets of the solar system.

Large antennas, telescopes, and satellite platform-bases in geostationary orbit will appear in outer space. The orbiting stations will function not only as scientific laboratories, industries, and extraterrestrial spaceports, but also as unique operations centers for servicing of various kinds of satellites and interorbital cargo shuttles and for assembly of large and complicated structures.

[Question]: The space missions of the present, and also those of the future, have much in common, which is only natural. But surely there are problems affecting the overall level of development of the space program and determining the path of its development?

[Answer]: Yes, there are. The development of the space program and its technical level are largely dependent on the space transport resources. Industrial development of outer space demands a substantial expansion and increase in volume of transport operations. And this process is only natural. The placement of space cargoes from the surface of earth into near-earth orbit, the delivery of crews and materials from space to earth, the interorbital transport of space facilities, and the launching of spaceborne laboratories on flight trajectories to the planets of the solar system—all this is done by means of transport systems and is largely dependent on their specifications. This applies to both present and future designs. It is one of the most complicated problems being tackled by scientists, engineers, and designers. Figuratively speaking, this is the formula for space acceleration.

[Question]: The space program is still too young for a strict evaluation of its accomplishments. In the three decades of the virtual onslaught on space, we have come an incredible distance, but at the same time the experts admit that the present rocket boosters are still far from perfection, and the cost of placing a payload in space continues to be quite high.

[Answer]: Quite right. But if you examine the history of the development of booster rockets, you will notice that the space vehicles and their performance have been improved over all these years. What I mean is, new designs, the specific impulse of the rocket engines, the ratio of the weight of "dry" rocket stages to their weight when fueled, and better reliability. This pertains to the Soviet Soyuz and Proton rockets, the American Atlas-Centaur, the latest versions of the West European Ariane, the Space Shuttle Program, and, finally, the powerful, superheavy booster rocket Energiya, created by a team of scientists and experts under the direction of chief designer and doctor of technical sciences B. I. Gubanov.

[Question]: We receive an especially large number of letters on the subject of Energiya. It is compared with the Shuttle, while at the same time it is represented as something entirely different among space transport vehicles.

[Answer]: Comparison here is hardly apt. The American reusable system—partially reusable—can place a payload of 30 tons into space and return with a payload of 15 tons. I say "partially," because technical difficulties have prevented American designers from developing a fully reusable system. The orbital stage is launched by means of two solid-propellant boosters, which later descend by parachute, and by the liquid propulsion system of the orbital stage itself with the fuel compartment that is jettisoned into the ocean after the sustainer liquid-rocket engines complete their burn. The latter engines return to earth as part of the Shuttle.

In terms of cost of payload delivery to orbit, the Shuttle remains on a par with the current booster rockets and is worse in this respect than the expendable booster rockets that are in the offing.

Energiya is a universal system with no counterpart anywhere in the world. I repeat, it is a universal booster rocket, designed to launch both reusable orbital vehicles

and large spacecraft used for scientific and economic purposes. It is able to place a payload weighing more than 100 tons into near-earth orbit. The launch weight of the entire system can reach 2,400 tons.

Let me repeat once again: Energiya is a rocket, not an orbital aircraft equipped with boosters.

[Question]: The Shuttle has nothing against publicity, although it carefully hushes up its weak points. Energiya only fairly recently began the flight testing phase. Please give us more details.

[Answer]: In the first place, it is a two-stage design with a the stages divided lengthwise and the payload positioned on the side. In other words, it is a "packet" of the four first-stage units around the central second-stage unit, with an asymmetrically arranged payload.

The second stage—which includes fuel tank system, the engine compartment, and the assemblies that secure the first-stage units and the payload—is the cornerstone of the new booster. The length of this stage is around 60 meters, the diameter is around 8. It has four single-chamber liquid rocket engines that operate on an oxygen-hydrogen mixture of fuel. The thrust of each of these is 148 tons at the earth's surface and 200 tons in vacuum.

As already mentioned, the first stage of the rocket comprises four strap-on units—unique rockets that burn an oxygen-kerosene fuel. The thrust of each strap-on unit is 740 tons at the surface and more than 800 tons in vacuum. These are the most powerful of all present-day liquid rocket engines.

As for the combined thrust, this is around 3,600 tons at the start of the flight. This is achieved by activating the engines of the first and second stages simultaneously.

[Question]: What happens after the launch? What is the operating sequence of the parts of the "packet," and what is their subsequent fate?

[Answer]: After the fuel of the strap-on units of the first stage is used up, they are separated, and the second stage of the booster rocket continues to function and places the spacecraft into a so-called reference orbit. After this, the engines of the booster unit (or of the spacecraft itself) are fired and the desired orbit is ultimately achieved.

The units of the first stage separate in pairs, after which they move apart and touch down in the desired area. They may be outfitted with return equipment and may be reused after appropriate servicing or repair.

The central unit (second stage) splashes down in the ocean.

[Question]: If I understand you correctly, the difference between Energiya and the booster rocket for the Shuttle is that, with the Shuttle, the engines of the second stage are on the craft itself, and therefore this stage operates only when the Shuttle, which is the payload, is attached. With Energiya, the second stage is not connected to the payload.

[Answer]: That is what makes Energiya universal. It can be used to place both returnable and nonreturnable cargoes in orbit. And the booster unit can be used for the most diverse of operations. For example, placing satellites into geostationary orbit, launching vehicles to distant planets, sending unmanned laboratories to the far reaches of the universe. There is a multitude of possibilities.

Energiya can be used to put put together not merely a universal orbital insertion system, but also a more economical one. Let me give some examples of the weight ratios.

With the configuration I mentioned, it is possible to place a payload of around 18 tons in stationary orbit, to launch unmanned stations weighing up to 28 tons to Venus or Mars, or to place vehicles of 32 tons into lunar trajectory.

The success of these and many other missions in the space program has been possible only because of the achievements marked in rocket engine design. Soviet scientists and designers have created liquid rocket engines with high specific impulse (the ratio of thrust to fuel consumption per second) and long overall operating life, which means that they are reliable in operation.

[Question]: You said "reliable." This is surely one of the most vital criteria?

[Answer]: Not only vital, but also difficult to achieve. Space technology is a special kind of technology. It is characterized not only by a complexity and multitude of units, systems, assemblies, and interrelationships, but also by special conditions of operation. Not only in outer space, but also at the launch pad. High specific load factors, vibrations, and substantial temperature differences.

Imagine what kind of structural materials are needed for the tanks, lines, hydroautomatic devices, sensors, etc., operating at cryogenic temperatures. The liquid oxygen that is used as the oxidizer, is cooled to a temperature of -186 degrees, while the liquid hydrogen (propellant) is cooled to -255 degrees Celsius. And the small, lightweight turbopump unit that produces 250,000 horsepower! All of these represent highly difficult scientific and technical problems.

Only ultraprecise automatic equipment can monitor the enormous quantity of changing parameters and make prompt, accurate decisions.

Such devices and systems have been created. There is an independent computer complex on board which executes a predetermined program. The vitally important systems and assemblies are backed up. Special emergency protection equipment investigates the status of various units, switching them off when necessary, and there are efficient systems for prevention of fire or explosion. The experts have analyzed more than 500 possible emergency situations and have found ways to counter them.

Extensive use of onboard computers has made it possible to develop active control systems. The use of such systems makes it possible to improve flight qualities and controllability and to enlarge the range of flight configurations.

[Question]: You are talking about the booster rocket. A structure so huge and complex requires similarly huge and complex ground facilities.

[Answer]: Of course. And this is another labor-intensive problem. For each, shall we say, element of the launch facility must be suited to all the features of Energiya—its power, its design, its operating characteristics, its fuel capacity. As a matter of fact, 90 percent of the immense launch weight of the rocket is fuel. It is easy to imagine what vast reserves of liquid oxygen, liquid hydrogen, and kerosene must be kept "on hand" in order to fill the booster within a certain interval of time and accomplish this in strict compliance with the safety requirements.

But this is a later phase. First of all, the rocket is assembled into the "packet" in the testing and assembly building. It is then transported to the launch pad, where it is put in position with a special erector. Power, pneumohydraulic, and electrical connections must be hooked up to the starter assembly. For these purposes, there is a special mating-launch transition unit, which remains on the launch structure after takeoff and can be reused.

There are many innovations: a gas-and-flame deflecting chute more than 40 meters deep, a multistory service tower of special design with work platforms for access to the various assemblies of the rocket, a fueling and drainage mast, lightning-rods 225 meters tall, and control rooms. All of this is quite different from the way it used to be at Baykonur.

The high degree of automation is the most signal feature of the new launch facility and all its constituent parts, bristling with a large array of essential technical, technological, and measurement systems.

Energiya itself, the ground facilities, and the landing strip are the product of the work of many design, research, production and construction groups.

[Question]: Please describe as briefly as possible the first flight-design tests of Energiya, and what will be the next phase?

[Answer]: Some believe that the new rocket is being tested to find out whether or not it can fly. This is a major error. Nowadays, if a new booster is built, you can be sure it will fly. Instead, the task is to check out the entire complex in different modes and to study the capabilities of all systems.

As we know, there is captive testing and full-scale checkout. The main goal of the designers and development engineers in May of last year was to obtain data about the serviceability of the entire complex in full-scale flight conditions, that is, to check out the actual design of the rocket, its propulsion units, and the multitude of onboard systems under conditions not possible during captive testing. This was in fact accomplished. The State Commission gave a favorable evaluation of the results. The design systems were acknowledged to be correct; the viability of Energiya was confirmed; and the high precision of operation of all onboard systems, the suitability of the ground facilities, and the correct and, if you will, logical sequence of ground operation phases were demonstrated.

The final segment of testing, during which it was necessary to run the command for separation of the payload, also passed without major incident. In this instance, a mockup of the spacecraft was used. Everything went according to program, until a slight malfunction in the circuitry of one of the onboard instruments of the "mockup" occurred. This prevented it from attaining the required speed after separation and reaching the proper orbit.

The first successful step provides a foundation for further advance. The flight testing will continue. The next phase will be the flight of a reusable orbital vehicle, the first launch of which is being busily readied. When will this occur? It is hard to give a definite date. Let me repeat: This is exceedingly complicated work, and haste makes waste.

[Question]: Yes, sometimes haste results in tragedy. A number of design imperfections and malfunctions that were tolerated during operation of the Shuttle system and the Challenger disaster are in large part explained by the haste with which that program was carried out under pressure from the Pentagon, which had assigned it the main role in carrying out special launches in behalf of the U.S. Department of Defense, especially in the recent plans involving SDI. What, in principle, is your attitude toward aerospace systems?

[Answer]: This is an interesting and promising area. By the way, the concept itself goes back to F. A. Tsander, in the 1920s. One should not think that the path chosen by the Americans is the only way to solve the problem. The British have a project for an aerospace plane, the Hotol. Nor has Energiya yet unfolded all its capabilities.

[Question]: Isn't our strategy for the development of space being altered to some extent in connection with development and placement in operation of new space equipment?

[Answer]: For the most part, no. We shall continue to do our utmost to see that now and in the future, space remains peaceful, international, and that it serves only the interests of the progress of mankind. As for the expanded work front and the advent of new trends scientific and technical, this is a natural process. The new scientific and technical achievements will be used to improve the orbital module complexes of the Mir-Kvant type and to create larger, permanently operating stations, other large structures, and, of course, space transport vehicles of greater sophistication.

The Soviet program continues to rely on utilization of the achievements of the space program in behalf of our country and all humanity. However, the future course of our space program will depend largely on the actions of the Americans.

[Interviewer]: Thank you for this chat. You have answered all the questions found in the letters of our readers. We wish you enormous success in your work.

[Answer]: Thanks.

Shuttle Flight Simulator at Central Aerohydrodynamics Institute

18660028 Moscow PRAVDA in Russian 24 Sep 88 p 3

[Article by A. Tarasov, correspondent]

[Abstract] The lengthy article reports on research, training and testing work which personnel of the Central Aerohydrodynamics Institute imeni Zhukovskiy (TsAGI) are conducting in line with a program for development of a reusable-spacecraft system.

An account is given of a simulated flight of an air-and-space ship (VKK) that took place inside a unit which the institute is using in level-flight tests. This simulator, which is said to be unique, is a piloting test stand which was specially developed for the VKK program. The author of the article shared the test stand's cockpit with Andrey Byushgens, head of a sector of TsAGI. The instruments on the cockpit's control panel are said to include a command-and-pilotage display device. Information displayed here enables the crew to monitor the route of the air-and-space ship after it reenters the atmosphere. The position of the ship's control surfaces during descent is monitored with the aid of a special scale. The cockpit is mounted on long hydraulic legs with an interlocking system, which makes it possible to simulate turns, zooming, air pockets and turbulence. A computerized optical collimation system is used to simulate runways and all kinds of fogs and clouds. Engineers, pilots, testers and whole crews of reusable spaceships reportedly have taken part in tests and training exercises employing this unit.

Development of air-and-space ships which will be capable of landing entirely in the automatic mode, regardless of weather conditions, is mentioned as one of the goals of the Soviet program. It will also be possible to land these craft manually, or in a combined mode in which the pilot can intervene immediately if any malfunction of automation equipment occurs. Doctor of Technical Sciences Vasiliy Aleksandrovich Yaroshevskiy, an associate of TsAGI, is credited with development of an analytical method of calculating trajectories for entries of spacecraft into the atmosphere. Automated equipment for controlling landings of air-and-space ships is being developed which will be capable of taking millions of possible combinations of flight parameters into account, it is claimed.

A model of a reusable spaceship with an ordinary airplane engine reportedly has been developed for level-flight tests. Aerodynamic testing is also being conducted, using miniature models of air-and-space ships. Mathematical modeling of the flight of such ships is done with the aid of a wind tunnel with a specially designed nozzle which was developed for these tests. Models coated with a thermodynamic paint are placed in this unit, a flow of very hot air is accelerated to Mach number 20 inside the tunnel, and the most scorching streams of air are determined by means of the paint. Heat and strength tests of full-size sections of airplane fuselages and wings are conducted in large chambers. These sections are faced with tiles made of a lightweight composite material.

A photograph is given showing the interior of the piloting test stand's cockpit.

FTD/SNAP

Shuttle Launch Scheduled for 29 October

18660029 Kiev PRAVDA UKRAINY in Russian 28 Oct 88 p 1

[TASS Report]

[Excerpt] Baykonur Cosmodrome, 26 October. A little more than two days remain until the launch of a multipurpose space rocket system, "Energiya"—"Buran". Following reports by specialists who summarized results of several thousand checking operations, the state commission today adopted a decision calling for the first test launch of this system. Preparations for fueling the launch-rocket and an orbiting spaceship will begin tomorrow, late at night.

The "Energiya" will be filled with almost 2,000 tons of liquid oxygen, hydrogen and hydrocarbon fuel in all. This figure alone indicates the capabilities of this new

heavy-class rocket whose first test took place on 15 May 1987. It left on its first flight with a mock-up of a satellite, but now the "Energiya" has to place the first Soviet reusable spacecraft, the "Buran", into the realm of zero gravity.

This space rocket system, whose tests open a fundamentally new stage in the advancement of Soviet cosmonautics, was transported in a horizontal position from an installation-and-preparation building, with the aid of four diesel locomotives. The whole system, which weighs several hundred tons, was then set up with jewel-like precision on the launching installation. The dimensions of the system are impressive. In outline, it resembles a five-domed cathedral 60 meters tall. At the broadest point, the main engine unit and four booster engines of the "Energiya" are about 20 meters in cross section. The orbiting spaceship, which resembles a huge white bird with black tail feathers, is fastened to the side of the rocket. This time, the ship will be sent on its space journey without a crew and make an unmanned flight.

FTD/SNAP

Shuttle Launch Complex at Baykonur

18660030 Moscow KRASNAYA ZVEZDA in Russian 28 Oct 88 p 3

[Article by M. Rebrov, Colonel]

[Abstract] The article reports on preparations for launching an "Energiya" rocket carrying a reusable orbiting spaceship, the "Buran". This spaceship is said to have a launching mass of about 100 tons. The launch was scheduled for 0623 hours Moscow time, on 29 October.

It is recalled that unique operations were organized for the purpose of transporting large units of the "Energiya" and "Buran" by air to the Baykonur Cosmodrome for assembling. The 201M, a special airplane designed by V. Myasishchev and personnel of manufacturer-plants, was used in these operations. Units weighing 50 tons were transported on some of these flights. The diameter of these items was 2.5 times the diameter of the airplane's fuselage. At the cosmodrome, the rocket and spaceship were assembled, joined together, and transported to the launching area with the aid of four 1,000-horsepower diesel locomotives.

The author reports that a new launch complex has replaced the test-and-experimental unit used in last year's "Energiya" trials. This complex is described as follows: "The central installation of the launching site is a sunken reinforced-concrete structure with five stories below ground level. Inside it is a cylindrical gas vent 20 meters in diameter. At a depth of 23 meters are three gas-escape channels with a 120-degree angle of slope. Equipment for monitoring checks is on the five lower stories, and a support-and-gripping device for securing the rocket is located a little above them.

"In the sunken structure are ventilating and temperature-control systems, a refrigerating center, compressors and air blowers. The temperature conditions of control-instrument containers and compartments of the launch-rocket are regulated from here.

"The launch complex includes two servicing towers, each of which is 64 meters tall; a revolving tower 100 meters tall; diverters 225 meters tall; a fuel-tank venting mast; a special system for emergency evacuation of the crew and maintenance personnel; a system for gas monitoring of the atmosphere, with automatic signaling; and a linking unit which is part of the launch-rocket's structure but remains in the launching installation after the rocket lifts off.

"A system called 'Earth—Shipboard' includes many supply lines. Fuel lines laid on scaffolds, more than 1,000 electric-cable 'tubes', and all systems are automated and controlled by modern computer technology."

A representative of the state commission told about operations which a command-and-measurement complex would perform during the upcoming launch. Four tracking vessels on the Atlantic and Pacific oceans and four satellite communications systems were scheduled to take part in gathering and transmitting information on the flight of the spacecraft.

A photograph is given showing the "Energiya" and "Buran" in the launch complex during pre-launch operations at the cosmodrome.

FTD/SNAP

Assembly and Test Buildings at Baykonur Cosmodrome

18660031 Moscow IZVESTIYA in Russian 29 Oct 88 p 8

[Article by Boris Konovalov, special correspondent]

[Abstract] The article recounts a visit to two buildings of the Baykonur Cosmodrome in which the reusable spaceship "Buran" and its "Energiya" launch-rocket were assembled and tested. The visit took place while preparations for the first launch of the "Buran" were in progress. Plans called for the spaceship to make two orbits around the Earth during its initial, unmanned flight. The main purpose of this experiment was to test the spaceship's performance during the most difficult parts of a flight—the launch and landing.

The cosmodrome's installation-and-testing building for "Energiya" rockets is said to be 240 meters square. Roof spans of this building rise to a height of 60 meters. The building in which the "Buran" was assembled and covered with heat-resistant materials is 37 meters tall and covers an area of 72,000 square meters. The spaceship's heat-shielding materials are briefly described on the basis of full-size engineering mock-ups of the ship which

were shown to journalists. The underside of the "Buran" is covered with thousands of black ceramic tiles that are heat-resistant. They are small in size, so that the ceramic covering will not break from the effect of thermal expansion of the ship's metal body as the "Buran" descends into the atmosphere, it is explained. The doors of the ship's cargo bay are also covered with tiles. The tiles are produced by a Soviet process which is said to be different from the process used in the United States.

FTD/SNAP

'Buran' Shuttle Automated Launch Complex
18660032 Moscow SOVETSKAYA ROSSIYA in Russian 29 Oct 88 p 2

[Article by V. Ovcharov, special TASS correspondent]

[Excerpt] Final pre-launch preparations have begun at the launch complex of the multipurpose space rocket transport system "Energiya"—"Buran".

"One of the main characteristics of the preparation schedule is the large number of simultaneous processes and the need for strict synchronization," Doctor of Technical Sciences V. Karashtin told us. "This requires synchronous operation of not only the launch complex's systems but also of the other ground-based complexes at the cosmodrome. First, this means supplying the launch with reliable, high-quality electricity from two independent sources, which duplicate each other. This task is difficult because of the extraordinarily high power consumption of the "Energiya" launch systems, which equals that of a rather large city. The high degree of automation of all pre-launch preparation and launch processes is based on the most modern mathematical methods for formalizing technological processes and on information technology that employs elements of artificial intelligence."

The scientist reported that the automatic control system at the launch complex is based on the so-called hierarchical principle. It has three levels, and the total volume of commands issued and signals received exceeds 100,000.

It is interesting that more than 4,000 actuators must be simultaneously controlled while all ten tanks of the "Energiya" are being fueled. In addition, the average temperature of the supercooled liquid hydrogen must be maintained with great accuracy and the level of a component in a tank prevented from deviating by more than 10 millimeters. It is known that at such low temperatures, there is a "cryogenic increase in metal strength". Taking advantage of this effect, designers were able to reduce the weight of the "Energiya".

Our hospitable hosts at the cosmodrome invited us journalists to the assembly and testing buildings of the "Energiya" and "Buran". Under the roofs of the huge space hangar-plants, work on the next vehicles is now under way. Even in the spacious buildings, their size is astonishing. We also had an opportunity to examine the orbiting spaceship, which everyone here affectionately calls the "little bird". It is about 30 meters long and 16 meters high. The area of the swept wing is 250 square meters, and the fuselage is 5.6 meters in diameter. The 38,000 light-weight, heat-absorbing ceramic tiles give the craft a somewhat fantastic appearance. These "scales" can withstand even temperatures up to 2,000 degrees.

For this craft, the test in space still lies ahead. But the first "Buran" is already prepared for flight.

FTD/SNAP

Shuttle Wind-Tunnel Tests at Central Aerohydrodynamics Institute
18660033 Moscow PRAVDA in Russian 2 Oct 88 p 1

[Article by A. Tarasov and V. Voronin, correspondents]

[Excerpt] Let us tell about an episode in the development of the orbiting spaceship "Buran".

A model of this reusable space shuttle was built according to all the rules of aircraft construction.

An ultrastrong composite material which was used had to be particularly stable and refractive where heat flows peak. For these peak zones to be ascertained and protective measures specified in the design of the actual spaceship, not tens or hundreds but thousands of test runs had to be conducted in a superhigh-speed wind tunnel.

The iridescence of a temperature-indicating paint which changes color in zones of intense heating is a truly bewitching spectacle. This paint has made it possible to dispense with measuring instruments and employ only motion-picture photography. Doctor of Technical Sciences Georgiy Maykapar, a leading specialist of the Central Aerohydrodynamics Institute imeni Zhukovskiy, thinks that the scientists would not have obtained so much information by any other means. Inside a shock tube, the temperature-indicating paint acts in a hundredth of a second. It would have taken more than a hundred transducers to obtain information of equal value.

(A photograph is given showing senior project engineer I. Kondratyev and A. Ivanov, a mechanic for aerohydrodynamic tests, setting up a model of the "Buran" in a wind tunnel.)

FTD/SNAP

Development of Aircraft for Transport of Shuttle, Energiya Components
18660034 Moscow VECHERNYAYA MOSKVA in Russian 27 Oct 88 p 3

[Article by D. Gay]

[Excerpt] At the very end of the 1970s, the firm of Vladimir Mikhaylovich Myasishchev, an outstanding Soviet aircraft designer, received the assignment of designing and building an airplane on which large and heavy structures of the future "Energiya" rocket and "Buran" spaceship could be transported from manufacturer-plants to Baykonur.

Myasishchev decided to put into practice a bold idea: transporting fuel tanks and compartments of the launch-rocket's main engine section and the future "Buran" itself on the 'back' of an airplane. The 201M, a strategic bomber designed by Myasishchev's firm, was selected for this task.

Not without reason was this aircraft chosen. Only an airplane with superb performance characteristics would be capable of delivering a gigantic load 8 meters in diameter and with a mass of more than 40 tons by air. The firm's development fitted this description.

The 201M had a tandem landing gear with the struts spaced far apart, under the wings. Cross winds could not affect this airplane. It was extremely stable during take-off and landing.

Myasishchev died shortly after. Doctor of Technical Sciences Valentin Aleksandrovich Fedotov was appointed senior designer for this project and became a chief designer a year later.

"We lengthened the airplane's fuselage by 7 meters," recalled V. A. Fedotov. "Instead of an ordinary single tail-fin unit, a twin tail unit was developed to provide greater stability, but mainly for the purpose of eliminating so-called buffeting—a powerful vortex flow which comes from the load the airplane is carrying. The frames and wing were reinforced, and new panels were installed on the fuselage. The overall result was a new airplane.

"This 'two-story' airplane took off with a load for the first time on 6 January 1982.

" 'Energiya' structures transported by air were covered with streamlined casings in an attempt to improve the aerodynamic shape of these loads, at least to some extent. These casings were returned to the manufacturer-plants on the return trips. Then they went back again to the cosmodrome, etc."

Among the other main participants in this painstaking work were Aleksandr Arkadyevich Bruk, one of the firm's leading associates, and V. A. Lyubakov, S. A. Pankov, B. I. Zorin, A. M. Kotelnikov, V. A. Shirinyants, N. G. Tvorogov and V. A. Korchagin.

(A photograph is given showing an airplane on the ground. A streamlined casing is mounted on top of the airplane.)

FTD/SNAP

Capabilities, Costs of U.S. and Soviet Shuttles Compared
18660035 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 28 Oct 88 p 4

[Article by German Lomanov, special correspondent at Baykonur Cosmodrome]

[Excerpt] Now that preparations for launching the multipurpose spaceship "Buran" are in progress, the question of whether we are lagging in space cannot be avoided. I discussed this question with various specialists, but received perhaps the tersest and most exhaustive reply from the chairman of the state commission:

"As far as the advancement of cosmonautics as a whole is concerned, we are not lagging behind the U.S. at all."

"The Americans have invested about 10 billion dollars in their 'Space Shuttle' program. How much has it cost us to develop the 'Energiya' and the 'Buran'?"

"The two programs are commensurate cost-wise; ours and theirs have cost approximately the same amount."

I should like at once to caution readers who have seen the "Buran" on television that its outward similarity to the "Space Shuttle" need not be considered significant. The American system differs fundamentally from the "Energiya"—"Buran" team; the latter is more versatile, and it can accomplish a substantially wider range of tasks.

On its first flight, the "Buran" will be tested in an unmanned version, although the spaceship is designed in general for a crew of two to four cosmonauts. The advantages of automatic control of flight hardly need to be demonstrated; it frees the crew, enables them to engage chiefly in experiments while they are in space, and heightens the whole system's reliability, since in the future cosmonauts will be able to take over control of the ship at any time.

FTD/SNAP

'Buran' Dimensions, Landing Site Facilities

18660036 Moscow KRASNAYA ZVEZDA in Russian 29 Oct 88 p 6

[Article by M. Rebrov, Colonel]

[Excerpt] The overall height of the spaceship "Buran" (along the fin) is about 16 meters. The ship's fuselage is 5.6 meters in diameter, its wing area is 250 square meters, its payload compartment is 4.7 meters in diameter and more than 18 meters long, and the crew's cockpits are also fairly spacious: 4 x 4 and 6 x 4.2 meters and more than 70 cubic meters in volume.

The initial total mass of the winged orbiting spaceship can be as great as 105 tons, and its landing mass is 82 tons.

The engines of the spaceship's combined engine unit are used for controlling the ship's movement in space, and aerodynamic controls (elevons, a steering rudder and an air brake) are used while the ship is gliding in the atmosphere.

A landing complex is located 12 kilometers from the launching installation. This complex takes in a combined command post and control tower, and a concrete runway 84 meters wide and 4,500 meters long. A so-called safety zone of 3 meters on each side of the runway and 500 meters on each of its ends should be added to these figures.

The landing complex includes radar equipment, range finders, "Kurs" and "Glissada" landing systems, a system for controlling air traffic in the vicinity of Baykonur, special transfer devices, and a six-story building with an instrument and scanning room on its top story. The combined command post and control tower is in charge of detecting and guiding the winged spaceship, the ship's landing approach, and stopping the ship, as well as post-flight servicing of the spacecraft and loading it for transportation to the installation-and-testing building.

The landing complex's radar equipment is capable of detecting the returning spaceship at a distance of 400 kilometers and an altitude of 40 kilometers. Landing approaches can be made from the "eastern" and "western" directions. Landing speed is 310-340 kilometers per hour and the landing distance is 1,100-2,000 meters. The "Buran" is equipped with a braking parachute 75 square meters in area. This parachute is jettisoned when the ship's landing-run velocity has decreased to 50 kilometers per hour. The movement of the "Buran" down the runway is followed with the aid of 16 television cameras installed along the runway.

Displayed on screens in the main control room are data on altitude, distance, azimuth, speed, alignment with the central line of the runway, programmed and actual flight paths, equipment in operation, and information from an escort airplane.

At present, these data pertain to a TU-154 laboratory airplane which is making test approaches to the runway. A high-speed escort airplane will take off before the "Buran" returns. This airplane is equipped with optical-and-television systems for tracking the landing of the orbiting ship, and equipment for monitoring of landing-gear lowering and gliding condition.

FTD/SNAP

Future Missions for Shuttle, Docking with 'MIR' Station

18660037 Moscow KOMSOMOLSKAYA PRAVDA in Russian 28 Oct 88 p 4

[Article by Sergey Leskov, special correspondent at the Baykonur Cosmodrome]

[Excerpt] The last preparations for launching the multi-purpose space rocket transport system "Energiya" and the reusable orbiting spaceship "Buran" are being completed at the Baykonur Cosmodrome.

"The majority of specialists agree that cosmonautics needs both reusable and non-reusable systems," related the chairman of the state commission for flight testing of the "Energiya" system and the "Buran" spaceship. "Flights lasting two to four weeks each are possible on reusable orbiting spaceships. They are quite capable of transporting large structures into orbit or removing them from orbit in that length of time, and the ships can dock with space complexes or platforms. That docking of the orbiting spaceship "Buran" with the second-generation station "Mir" is in our plans is no secret. It must also be remembered that a number of costly satellites now remain in orbit after their service life has expired, but here are reusable orbiting spaceships which could bring them back to Earth."

FTD/SNAP

Shuttle Launch Aborted 51 Seconds Before Liftoff

18660038 Moscow PRAVDA in Russian 30 Oct 88 p 1

[Article by A. Tarasov, special correspondent at the Baykonur Cosmodrome]

[Excerpt] Flight Control Center. Deviations in the operation of a launch support system occurred during the final stage of preparing the launch-rocket "Energiya" and the orbiting spaceship "Buran" for launching. A command to halt further work was issued automatically in connection with this. The problems that have arisen are now being eliminated.

A further announcement of the time and date of the launch will be made.

It was hoped at first that the launching process would soon be resumed, but then came the announcement that draining of the "Energiya" rocket's fuel had begun. This

procedure, which launching crews are not very fond of, held up all traffic at the cosmodrome. Journalists found out the reason for this a few hours later, at the main command bunker. Strangely enough, General-Major of Aviation Vladimir Gudilin, head of the Baykonur Cosmodrome's testing administration, did not appear upset.

"This is a case of an irregular situation whose possibility is taken into account," he said. "It demonstrates that the automatic safety system developed for the launch complex of the rocket and spaceship was functioning reliably. For reasons which are now being ascertained, one of the service stands failed to move back from the launch-rocket 51 seconds before lift-off. To be more precise, it was seen to move away, but the computer which verifies the launch readiness of all systems did not receive the signal that this was happening. An aiming platform which controls gyroscopes is held by this stand up until the last seconds. After polling all signals, the computer did not find the response of this structure and immediately stopped the launch program. The rocket or the spaceship would be in danger of catching on the structure otherwise.

"As many as 140 launch situations of this kind can arise at our complex, and the main thing is to foresee and counter them," said Vladimir Yevgenyevich in conclusion. "Despite the delay, one of the most important systems has confirmed its operational fitness. And the rocket and spaceship have passed a whole series of checks and tests. So I have told my men that this is a dress rehearsal, and they are permitted to go on working."

FTD/SNAP

Second Launch Attempt Rescheduled for November

18660039 Moscow KOMSOMOLSKAYA PRAVDA in Russian 30 Oct 88 p 4

[Article by S. Leskov, special correspondent at the Baykonur Cosmodrome]

[Excerpt] The fuel tanks of the "Energiya" second stage are filled with hydrogen and oxygen, with the fuel reaching a total weight of 2,000 tons. It would seem superfluous to explain what an explosive mixture this is and why extraordinary safety measures are necessary.

As was announced by General-Colonel A. A. Maksimov, the Ministry of Defense's chief specialist on reusable transportation systems, a special-regime zone with a 15-kilometer radius is being set up around the launch complex. Thirteen hours before launch, when fueling of the rocket beings, all movement in the zone will cease and access to it will be closed.

"When is the next launch possible?"

"We are ready to repeat the attempt rather soon," said General-Major V. Ye. Gudilin, head of the Baykonur Cosmodrome's testing administration for launch of the multipurpos space rocket transportation system "Energiya". "After draining the fuel, we will recheck the launch-rocket and the orbiting spaceship, carefully analyze the situation with the service stand, and refill the fuel tanks. Moreover, after four months of intense preparatory work, people need a rest. I think that the launch will be rescheduled for after the [November] holidays."

FTD/SNAP

General Maksimov Comments on Cause of Launch Postponement

18660040 Moscow KRASNAYA ZVEZDA in Russian 4 Nov 88 p 4

[Article by M. Rebrov, Colonel]

[Abstract] The article is an interview with General-Colonel Aleksandr Aleksandrovich Maksimov, chief specialist of the USSR Ministry of Defense for reusable space rocket transport systems and prospects for their advancement. Maksimov comments on the reasons for postponing the launch of the "Energiya" rocket and orbiting spaceship "Buran" which was scheduled originally for 29 October.

On the morning of the 29th, all pre-launch operations proceeded smoothly until 51 seconds before lift-off, when the command to stop was given automatically, Maksimov recalls. The trouble was found to lie in a special platform of one of the launch complex's servicing beams. Installed in this platform is a system for correcting onboard gyroscopes of the "Energiya" rocket's aiming system. This platform had moved away from the rocket, but not in the manner prescribed by the program. Maksimov notes that the complex's computers could have been switched off and the launch accomplished manually, but at the risk of damaging the spaceship if the platform was in its way. The state commission therefore decided in favor of postponement. As a member of this commission, Maksimov says that he has no doubts as to the computer's reliability. He mentions in conclusion that a commission has been created to investigate the situation and take technical measures to prevent similar ones from occurring in the future. FTD/SNAP

'Buran' Shuttle Launch Scheduled for 15 November

18660041 Moscow IZVESTIYA in Russian 13 Nov 88 p 1

[Text] During preparations for a test launch of the multipurpose space rocket transport system "Energiya" and the orbiting spaceship "Buran" at the Baykonur Cosmodrome, the process was stopped automatically, as

has been reported. It has been established that this was caused by delay in separation of an instrument unit of the azimuthal orientation system from the body of the launch-rocket.

The causes of this delay have now been eliminated, and the multipurpose space rocket transport system "Energiya" and the orbiting spaceship "Buran" are undergoing a series of pre-launch preparatory operations.

The launch is scheduled for 15 November, at 0600 hours Moscow time.

FTD/SNAP

Deputy Chief Designer Filin on Modification of Guidance Adjustment Connector

18660042 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 15 Nov 88 p 1

[Article by V. Ovcharov, correspondent]

[Excerpt] Baykonur Cosmodrome, 14 November. Almost 700 floodlights have again lit up the launch complex on which the multipurpose space rocket system "Energiya"—"Buran" towers. Final operations for preparing this system for the launch which is scheduled for November 15 began here this morning.

At a meeting with journalists, V. Filin, deputy chief designer of the "Energiya" system in charge of experimental perfecting, reported: "As is known, launching preparations were stopped automatically on 29 October, 51 seconds before lift-off. This was caused by delayed separation of a so-called adapter beam on which instruments for azimuthal orientation of the rocket were installed. An analysis has demonstrated that this resulted, strangely enough, from excessive structural complexity of the assembly which connects this adapter to the side of the rocket. Incidentally, such an adapter was not used in the first launch of an "Energiya" rocket because its payload did not have to be placed into orbit with high precision then.

"In other words, computer polling which was done following the command to repel this structure from the side of the rocket recorded the fact that this was not happening. To be more precise, this operation actually took 38 seconds instead of the three allotted for it. Consequently, the platform of the unit for emergency evacuation of cosmonauts, which is then supposed to move the adapter away, did not even succeed in going into operation. In accordance with the results of the analysis that has been made, the assembly which connects the adapter to the side of the rocket has been modified. It has become simpler but more reliable, which has been confirmed by tests employing an experimental unit. Irregular situations occurring through the fault of this assembly thus have now been precluded."

FTD/SNAP

TASS Reports Launch and Landing of 'Buran' Shuttle

18660043 Moscow KRASNAYA ZVEZDA in Russian 16 Nov 88 p 1

[TASS Report]

[Text] A multipurpose "Energiya" space rocket transport system with a reusable spaceship, the "Buran", was launched from the Soviet Union on 15 November 1988, at 0600 hours Moscow time. The orbiting spaceship went into the calculated orbit at 0647 hours.

The test program calls for the orbiting spaceship to make a flight of two orbits around Earth and land in the automatic mode at the Baykonur Cosmodrome at 0925 hours Moscow time.

After accomplishing a flight of two orbits around Earth, the orbiting spaceship "Buran" landed on a landing runway of the Baykonur Cosmodrome on 15 November 1988, at 0925 hours Moscow time.

Such a landing was made in the automatic mode for the first time in the world. The program of the test launch of the multipurpose space rocket transport system "Energiya" and the reusable orbiting spaceship "Buran" was carried out in its entirety.

(A photograph is given showing the "Energiya" and "Buran" at the moment of lift-off.)

FTD/SNAP

Details of 'Buran' Shuttle Flight

18660044 Moscow KRASNAYA ZVEZDA in Russian 16 Nov 88 p 4

[Article by M. Rebrov, Colonel, special correspondent at Baykonur and Flight Control Center]

[Abstract] The test flight of the unmanned reusable spaceship "Buran" took place on 15 November 1988. This flight was preceded by more than 6,000 tests, including tests of individual structural components of the spaceship. The flight was intended also for further testing of components of the spaceship's "Energiya" launch rocket, including its RD-170 engines, which are said to possess record thrust characteristics, and sustainer engines. This rocket's turbopump units and the turbine of its fuel pumps have capacities of more than 250,000 and 100,000 horsepower, respectively. Electrohydraulic systems of the sustainer engines' steering drives develop a total force as great as 50 tons and make it possible to place a payload into orbit with a precision as high as one percent of the range of transpositions, it is claimed.

The author reports that the rocket's self-contained guidance system went into operation at 0536 hours and emergency protection equipment at 0545 hours on the day of the launching. The launch began on schedule, and the rocket's first-stage booster engines separated in pairs at the 165th second of the flight. The second stage separated at the 486th second, when the "Energiya" had reached an altitude of about 160 kilometers and was traveling at a speed 30-40 meters per second below orbital speed. The spaceship's engines were started at 0636.19 and operated for 67 seconds. A few minutes later, the engines were fired again and operated for 42 seconds. The "Buran" was placed into an orbit with the parameters: altitude—252-256 kilometers; period of revolution—89.45 minutes; orbit inclination—51.6 degrees.

After the spaceship's onboard systems had been put into the mode of independent orbital flight, comprehensive tests of the ship's structure, combined engine unit and onboard electronic, communications, automation, actuating and control equipment began, the author relates. Installed in the ship's cockpit were several computer systems which process flight data and coordinate it with testing problems and objectives stored in a computer's memory. As compared with computers of "Soyuz" spaceships, the information-processing speed of computers of the "Buran" is several times as high, and their online storage capacity is many times as large, according to the author.

The author reports that the testing of the "Buran" proceeded smoothly. The spaceship's braking engine was fired at 0820.03. During the final stage of flight, the "Buran" glided at hypersonic speed for a long time. Stability was maintained by means of the ship's wing. Elevons were used for roll and pitch control, and yawing was controlled with the aid of the steering rudder. A special armor made of completely new materials with high heat resistance protected surfaces of the spaceship against the action of plasma generated during flight through the Earth's atmosphere. This armor consists of more than 38,000 ceramic tiles with different thicknesses.

FTD/SNAP

Comments of Pilot of MIG Chase Plane

18660045 Moscow PRAVDA in Russian 16 Nov 88 pp 1,6

[Article by A. Tarasov, special correspondent at the Baykonur Cosmodrome]

[Excerpt] Pilot-cosmonaut I. Volk aimed a camera with a telescopic lens at the launching of the "Energiya". A MiG airplane for aerial observation of the rocket's launching and ascent made a takeoff run down a runway. Conversations between the Flight Control Center and scientific ships were heard over a loudspeaker. Together with satellite systems, these vessels created a whole web of radio links for telemetry of the "Buran". When the landing program went into operation, a MiG again taxied onto the runway, this time to meet the spaceship.

Last evening, a tall, slender, good-looking and brave fellow sat and watched a video recording attentively in Central Television commentator Sergey Slipchenko's hotel room, which had been converted into a traveling tape-editing studio. This fellow was Magomed Tolboyev, a test-pilot of the Flight Research Institute and one of the support personnel for tests of the "Buran" here at the cosmodrome. On the screen of a monitor, MiG and TU-154 airplanes were seen taking off, executing turns in the air and coming in for landings. Magomed recognized his own flying style and that of his comrades Rimantas Stankyavichyus and Ural Sultanov.

Magomed explained what his tasks were at the time the "Buran" was being escorted: "Inspection of the aircraft from below. Inspection of the landing gear. Here is where it lowered its speed brakes and wing flaps. There's a TU-154 descending on automatic..."

A psychological question: "Is this difficult?"

"We have learned how to keep the system in our heads and trace the dynamics of aircraft operating in the automatic mode. As soon as an error occurs, or a series of deviations preceding an error, the situation must be appreciated quickly—in two or three seconds—and the automation equipment switched off."

Judge the professional difficulty of this for yourself. After spreading its air brake, the orbiting spaceship proceeded with a sharp dynamic steeper than a combat dive, changing its speed from 5,000 and 300 kilometers per hour. There was then no pilot in its cockpit who could take into account the maneuvers of the MiG flying alongside while maneuvering in this slalom leading to the runway. To pilot one's airplane for two, sensing the behavior of both the aircraft and the spaceship, took skill on the level of artistry.

(A photograph is given showing the "Buran" landing on the runway. A MiG escort airplane appears in the air in the background.)

FTD/SNAP

Design Features, Flight Monitoring of 'Buran'

18660046 Minsk SOVETSKAYA BELORUSSIYA in Russian 16 Nov 88 p 4

[Article by V. Ovcharov, correspondent at the Baykonur Cosmodrome]

[Excerpt] The first Soviet reusable spaceship, "Buran", has passed its examination in space with honors.

We saw this spaceship in a building [of the Baykonur Cosmodrome]. Almost all of the ship is covered with ceramic tiles which have no counterparts in the world and in many ways are more highly perfected than in other countries. A computer determined the dimensions and thickness of each tile on the basis of mathematical calculations of the spaceship's body; a program was then stored in machine tools with numerical programmed control, which machined these remarkable products with a precision of tenths of a millimeter.

It is only because of these tiles that the spaceship, which is made of aluminum alloys, steel and titanium, does not burn up while returning to Earth. Thirty-six meters long and 16 meters high, the ship can take a crew of two to four plus another six passengers on board. Its cargo bay is 18 meters long and 4.7 meters in diameter and can hold up to 30 tons. The volume of the crew's cockpit is more than 70 cubic meters. The cockpit has six windows with an overall glass area of 2.25 square meters.

A pair of MiG-25 airplanes took off shortly before the launch. Test-pilot M. Toroyev and S. Zhadovskiy, a motion-picture cameraman, flew to a certain altitude for the purpose of filming the launch and the powered phase of the system's flight from there. When the phase of placing the system into orbit began, more than 5,000 parameters characterizing the system's operation were transmitted to Earth via telemetry channels. They were supplemented by 20 digital streams, each of which contained another 800-1,000 parameters.

Almost all of the spaceship's systems were in operation while it was flying around the Earth. Among them was an onboard television system, with the aid of which we saw the Earth's surface. When the program of the orbital flight was completed, the ship turned around and fired its braking engines. It thus began the trip back to Earth tail-first. It then returned to its previous position and rushed toward the landing runway.

The spaceship had been awaited there for a long time. A MiG-25 took off into the sky again. Special radar systems locked on to the "Buran" at a specified distance and began to guide the ship into the proper corridor. Whereas automatic landing for airplanes was perfected long ago, a spaceship was making such a landing for the first time. This operation was rehearsed dozens of times with the aid of laboratory aircraft and a mock-up of the "Buran" before the decision was made to permit such an independent flight of the spacecraft.

FTD/SNAP

Press Conference on Results of 'Buran' Flight

18660070 Moscow KRASNAYA ZVEZDA in Russian 7 Dec 88 p 1

[Excerpt] The successful launch of the multipurpose space rocket system "Energiya"—"Buran" was the topic of a press conference for Soviet and foreign journalists which took place in the press center of the USSR Ministry of Foreign Affairs on 6 December. Numerous questions from correspondents were answered by A. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research; V. Barmin, general designer of launch complexes; B. Gubanov, chief designer of the space rocket system "Energiya"; V. Lapygin, general designer of a scientific production association for automation and instrument building; G. Lozino-Lozinskiy, general director and chief designer of a scientific production association; Yu. Semenov, chief designer of reusable spaceships; and Yu. Filaretov, chief designer of radio systems for air traffic control, navigation and landing.

It was stated that the "Energiya"—"Buran" system has been developed exclusively for peaceful purposes. It was announced to the journalists that two more airfields for operation of the spaceship are being built in the western and eastern regions of the USSR. These airfields are needed in order to make landing approaches possible from any orbit. At the same time, experience with the initial flight has demonstrated that the relatively short landing run of the "Buran" on a runway enables the spaceship to land also at any nonspecialized first-class airfield.

The "Buran" is not the only craft of its kind in existence. A number of other spaceships are at various stages of readiness, and second flight of the "Buran" could be made without difficulty during the months immediately ahead. Specialists noted, however, that no such task has been set as yet.

'Buran' Designer Semenov Interviewed

PM0712153588 Moscow IZVESTIYA in Russian 6 Dec 88 Morning Edition p 2

[Interview with Yu. Semenov, chief designer of reusable spacecraft, by scientific observer B. Konovalov, under the "Viewpoint" rubric: "Why Do We Need 'Buran?'"; first paragraph is IZVESTIYA introduction]

[Text] Yuriy Pavlovich Semenov was born in 1935. He graduated from Dnepropetrovsk State University. He began his production activity in a design bureau under the leadership of M.K. Yangel. Then he moved to S.P. Korolev's design bureau. He is now deputy general designer of Academician V.P. Glushko's "Energiya" science and production association and the chief designer of "Buran" and of manned space ships and stations. Yu.P. Semenov is a Hero of Socialist Labor, corresponding member of the USSR Academy of Sciences, and Lenin and State Prize winner.

[Konovalov] "Buran" is undoubtedly an outstanding scientific and technical achievement. But any project should be comprehensively justified. If you leave aside the question of load capacity, then functionally only one innovation has been accomplished—it is now possible to

bring back loads, and quite large loads, from orbit. At the same time the majority of satellites during the time of their operation, and that time is now up to 5 years, become obsolete and it would be pointless to use them again after repair. What seems to you to be the justifiable sphere for "Buran's" use?

[Semenov] The return to earth of satellites which have come to the end of their useful life for repeat launching or simply their recovery from orbit in connection with unpredicted failures is only one of the tasks which the "Buran" space craft can resolve. It is hard to expect any particular "rich pickings" here if you consider that, as you rightly note, satellites become obsolete with the passage of time. As a rule the launching of the "Energiya-Buran" complex for this purpose alone is indeed economically disadvantageous. That applies primarily to standard, large-series satellites like communications, meteorological, and other satellites. But in individual cases the return to earth of a unique and very expensive research complex may be extremely important. Of course, the recovery of faulty satellites with nuclear devices will always be justified because otherwise the radioactive pollution of the earth's atmosphere and surface is possible.

Nonetheless we regard the task of bringing back a satellite as one which is resolved incidentally, while the main task is to launch expensive spacecraft equipped with unique scientific instruments—for instance a large optical telescope with complex electronic equipment. Projects requiring the creation in orbit of large-scale radio telescopes, antenna systems, solar orbital power stations, and interplanetary complexes, that is, extremely expensive installations created singly and requiring servicing by manipulators, robots, and skilled specialists. Naturally, it is sensible to put all this in space in a single journey.

The "Buran" space ship can also be used in individual instances as a space scientific research laboratory during whose flight an in-depth study of the efficiency of any very important complex of apparatus can be carried out so that when it returns to earth its development can be continued under conditions of total clarity. A whole series of modifications to the design and systems of manned space craft emerged thanks to cosmonauts who observed them in orbit, worked with them in space, and repaired them during the flight process. With the emergence of the "Buran" space ship it is possible to apply this valuable experience to unmanned near-earth craft as well. When in 1986 it was decided to raise the orbit of the "Salyut-7"-"Cosmos-1686" complex, which had been operating for 5 years, for prolonged operating life tests [resursnyye ispytaniya] in automatic mode, even at that time an option was examined for using the "Buran" space ship to return individual sections [bloki] of the station to earth in the period 1995-2000. This operation will give specialists truly priceless data on the behavior of the structure, materials, and apparatus. This measure alone may more than replace all ground-based studies which are now being carried out in this direction and produce an enormous saving.

That is just a number of the tasks which it is planned to resolve using the "Buran" space ship.

[Konovalov] "Buran" can raise 30 tonnes in its payload bay to an altitude of 250 km. But the same thing can essentially be done with the aid of two "Proton" rocket launches, docking in space the payload they have put in orbit. That will be far cheaper than using the more powerful and expensive "Energiya" rocket. At last year's congress of the International Astronautical Federation, O.N. Shishkin, the spokesman for the USSR Ministry of General Machine Building, stated that in the opinion of Soviet specialists there is no sense in using reusable space ships to put freight in orbit—one-time rockets are preferable from the economic viewpoint. Has the position of Soviet specialists not changed?

[Semenov] Fundamentally the position of Soviet specialists has not changed, apart from those aspects which we have already mentioned. This viewpoint is based on the cost of putting one kilogram of freight in orbit. The question of reducing this cost remains very topical. It is no secret that in our country and abroad one kilogram of freight put in orbit costs thousands of rubles (and thousands of dollars). And the "Energiya" booster rocket is no exception to the rule. So far only the space craft is reusable in the "Energiya-Buran" complex. The booster stages [raketnyye bloki] are used only once, and this makes each launch considerably more expensive. That is why work is now under way to salvage the strap-ons and reuse them, but here it should be noted that bringing the booster rocket to the point where it can be used repeatedly is a complex and expensive task. The recovery of expenditure on this work depends to a considerable extent on the anticipated frequency of the launches of the "Energiya" booster rocket in the future. A no less important question is the reliability of the returned strap-ons. U.S. specialists have advanced somewhat further in this field (in the "Space Shuttle" system they salvage the solid-fuel boosters) and, as their experience has shown, reuse requires expensive work, which virtually cancels out the saving.

So far, means of orbital insertion which are used only once are cheaper. That is why it is planned to build our space program on a sensible combination of methods of orbital insertion. Alongside the "Energiya-Buran" complex it is planned to use single-use rockets in the future too.

In contrast to us, U.S. specialists use the "Space Shuttle" system as the main means in all cases of orbital insertion. This is done because there is no way out of using it, as the main funds were in the past concentrated on developing this system and cheaper single-use methods of orbital

insertion were underestimated. Their creation was suspended. Today this decision has been recognized as erroneous and the production of single-use "Delta-2" rockets has been organized.

Having at their disposal means of orbital insertion of varying capacity and operations for automatic docking in orbit, Soviet specialists can implement virtually any projects requiring the creation of large space vehicles. The project now under discussion for a manned expedition to Mars with a mass of over 450 tonnes can serve as an example. It is planned to assemble the interplanetary spacecraft in the earth's orbit from individual units put into orbit by the "Energiya" rocket with the participation of the "Buran" space ship.

[Konovalov] The altitude of "Buran's" basic [opornaya] orbit is 250 km. Long-term orbital stations, like "Mir," for instance, work at higher orbits—on the order of 450 km. That means that to dock with the station it is necessary, in addition to 14 tonnes of fuel, to have additional tanks. They can be made only at the expense of the payload. How much then will remain of the 30 tonnes of potential payload if "Buran" has to rise to an altitude of 450 km?

[Semenov] Naturally, one of "Buran's" main tasks is to service orbital stations and individual satellites whose operational orbits can be quite high—450 km and more. "Buran" has this potential, including the necessary fuel tank capacities. Indeed, the maximum capacity of the tanks is 14 tonnes. Here, when it is necessary to put a payload with a mass of less than 30 tonnes in a basic orbit of 250 km at an inclination of 51.6 degrees the fueling is 8 tonnes. With 14 tonnes of fuel the "Buran" can carry out orbital transfers up to altitudes of 450 km with a payload mass of 27 tonnes. When it is necessary to increase altitudes to 800-1000 km, the possibility is envisaged of providing "Buran" with fuel tanks with an additional capacity of 14 tonnes of fuel. [Konovalov] "Buran" is a freight and passenger ship, with the same function as the "Soyuz." But after all just one of "Energiya's" four "side boosters" ["bokovushki"] can put 12 tonnes of payload in orbit. This makes it possible to create a new transport ship 5 tonnes heavier than the "Soyuz," which would have a sufficient fuel reserve for maneuvering and could carry more freight, and its launch would be immeasurably cheaper. Will the result not be that, by creating "Buran," we will be "using cannon to shoot sparrows?"

[Semenov] Indeed, the "side boosters," as you call them, were created on the basis of a series-produced booster rocket. And we are examining the future possibility of creating a cargo spacecraft purely for freight based on this booster, which should replace the present "Progress." We propose almost halving the cost of the delivery of one kilogram of freight to the station by this space ship compared with "Progress." But I think this solution should be regarded as a temporary one, until the appearance of a reusable freight and passenger complex (a reusable booster unit and space ship) smaller than the "Energiya-Buran system.

It is technically impossible to create a reusable freight and passenger complex of the required size on the basis of one "Energiya" "side booster." And in my opinion it is economically inexpedient to produce something similar to the "Soyuz" but of larger size.

The question of creating a freight and passenger complex, as reusable as possible, for regularly servicing orbital stations is a topical one today and is being examined both in our country and abroad—in the United States, France, and Japan.

To service the "Mir" station we have today the "Progress" and "Soyuz" space ships which are so far considerably cheaper than existing reusable means. "Buran" can take part in individual experimental operations together with the "Mir" station. That is part of our plans.

[Konovalov] Initial U.S. expenditure alone on the "Space Shuttle" project were in excess of $10 billion. What is our expenditure? And when can we expect the "Energiya-Buran" space complex to justify the funds invested? THanks to which scientific and technical avenues can this happen?

[Semenov] Expenditure on the creation of the "Energiya-Buran" system is comparable with the cost of the "Space Shuttle" program. It is indisputable that these complexes outwardly have a lot in common. But here it must be stressed that the "Energiya-Buran" system has a number of technical advantages compared with the U.S. system and was created using our own engineering solutions, materials, and technologies. This should be viewed not only as a very big step in cosmonautics. Although all these developments were made with regard to this system, their use in daily life can already bring our national economy revenue running into many billions and considerably in excess of expenditure on space research.

For instance, the electrochemical generators of the module type using ecologically clean components (hydrogen-oxygen) could have the most varied application and heat insulation materials working at temperatures of up to 1,500-1,600 degrees are tens of times more effective than any others. Manufacturing processes for the production of structures from various new materials, including cellular composites reducing the structures' weight [illegible] percent, and promising beryllium and titanium and nickel alloys could be widely introduced.

The methods developed for testing complex technical systems, the universal highly reliable computer complexes, and methods of developing and debugging software. We must not underestimate the importance of effective methods of automatic diagnosis and prevention

systems for measuring physical parameters, and television systems for displaying and recording information with a high degree of resolution and sensitivity. All this has been done to the standard of world achievements.

In addition to economic expediency, the equipping of our aircraft with all-weather landing facilities, the introduction of remote control and guidance facilities using communications channels via relay satellites for all types of transport, and the use in atomic power engineering of a computer control complex with a built in diagnosis system will make it possible to rid ourselves of many ordeals and potential tragedies. And these are just a few examples of the "incidental" use of the achievements obtained during the development of the "Energiya-Buran" complex. [Konovalov] The impression is created that "Buran" will be vitally necessary only with the appearance of large orbital stations and space factories, when it will be necessary to set up a large-scale freight flow from earth to space and back to earth and to transport many people. Am I wrong?

[Semenov] Yes, in our country and abroad research is being carried out most seriously in connection with the study of the possibility of organizing in orbit the production of materials in the interests of various sectors of industry and of biological preparations for medicine with properties which cannot be obtained under conditions on earth. It seems to me that this work will produce tangible results as early as the next decade. All this work is connected with a large-scale freight flow from earth to space and back to earth. And the "Buran" space ship is irreplaceable for bringing back to earth the output from these production facilities.

It should be noted that the orbital complexes of the future will undoubtedly include unique instruments, large, complex girder structures and power systems whose deployment is inconceivable without the participation of the "Buran" space ship in this work.

"Buran's" transport only of people to orbital complexes is hardly likely ever to be expedient.

But, as has already been noted, "Buran" also has independent tasks unconnected with the servicing of future orbital stations.

[Konovalov] The "Energiya" rocket opens up scope for creating large satellites and orbital and interplanetary stations. But it raises very keenly the question of the cost of space projects. Evidently a sensible way out of the situation is international cooperation. Are you prepared to offer the international community the shared use of the "Energiya" rocket?

[Semenov] You are right, "Energiya" opens up truly boundless opportunities for developing space. But it is also well known that further headway is being held back by the large expenditure which cannot be avoided in taking on a particular project.

All more or less simple tasks which required relatively small expenditure have already been resolved. The projects of the future undoubtedly demand the involvement of the world community's scientific and technical potential. Implementing individual projects through the efforts of just one country, however wealthy, is inconceivable. For instance, take the implementation of a manned expedition to Mars or the organization of direct communications for every inhabitant of earth in any corner of the earth. This solution of this problem is connected with the need to put into stationary orbits multi-ton relay satellites equipped with large receiving and transmitting antennas many meters wide. With the appearance of the "Energiya" booster rocket the launching of such satellites has become perfectly feasible. But international cooperation on a shared basis is essential to produce hundreds of millions of ground-based autonomous portable radiotelephone apparatuses. Dozens of such projects can enumerated. I think the international situation today makes it possible to look with optimism on the creation of planet-wide cooperation.

We are in favor of space becoming an arena for peaceful international cooperation and we are ready to make the "Energiya-Buran" complex available for planet-wide use.

Commentary on Flight of 'Buran' Shuttle by Designers Glushko and Semenov

18660018 Moscow PRAVDA in Russian 17 Nov 88 p 3

[Article by V. Glushko, academician, general designer of the "Energiya"-"Buran" rocket-space system, manned ships and stations, and Yu. Semenov, corresponding member, USSR Academy of Sciences, chief designer of the "Buran" orbital ship, manned ships and stations: " 'Buran' Over the Planet"]

[Text] The first test flight of the "Buran" shuttle opens a new page in the Soviet space research program and is a natural step considerably broadening the work carried out by our scientists in circumterrestrial space.

Henceforth Soviet space technology has not only the means for putting an artificial earth satellite and loads of great mass into orbit, but also means for their return to the Earth.

The "Buran" ship is a logical continuation of the work of Soviet designers of space technology. It integrates all the accumulated experience of Soviet rocket-space and aviation technology.

An aircraft design of the "tailless" type with a low-placed triangular variable sweptback wing served as the basis for ship construction. It makes an impression due to its inspiring size. Its total length is 36.4 m, the wing span is about 24 meters and its standing height is 16.5 meters. Its load compartment could be a good railroad car which can freely hold a payload with a weight up to 30 tons with a total launching weight of the ship up to 105 tons.

The ship was launched using the "Energiya" universal booster rocket. Flight in orbit occurs traditionally with execution of all the operations characteristic of a space vehicle, but here the descent into the Earth's atmosphere occurs the same as an ordinary aircraft with landing at a specially prepared airport. The landing speed is about 340 km/hour, the same as a modern fighter plane. A single airport located near the launching area at Baykonur cosmodrome has now been constructed and put into operation for the landing of the first "Buran" ship. The airport is a unique structure. Suffice it to mention that the landing strip is about 5 km long and 80 m wide with rigorous specifications on the quality of the surfacing. The airport is supplied with all the necessary modern radio facilities ensuring all-weather landing, including automatic landing. In the subsequent period, when the ship is put into operation, plans call for activating two specialized airports in the western and eastern parts of the country for broadening the operational capabilities of the complex.

The ship's body is not pressurized. It can be divided arbitrarily into three compartments: prow, middle (payload compartment) and tail. In the prow compartment there is a pressurized fully welded inserted cabin with a total volume of more than 70 cubic meters which in the future will hold the crew and the main part of the apparatus, ensuring the ship's flight in a rocket-space complex, autonomous flight in orbit, descent and landing.

On the outer side of the body there is a specially developed heat insulating covering. Two types of covering are used, depending on the place to which it is applied on the body in the form of "tiles" fabricated from a superfine quartz fiber and flexible elements of high-temperature organic fibers. A construction material based on carbon is used for the most heat-stressed sectors of the body surface, such as the wing edges, the prow cap and leading edge of the keel.

Assurance of normal thermal conditions for the ship's structure is an extremely complex problem. Indeed, in the course of passage through the dense layers of the atmosphere the temperature exceeds 1600 degrees on individual "windward" surfaces due to drag, whereas the temperature of the body covering must not exceed 150 degrees. In mentioning the heat-shielding covering it must be noted that the problem of creating a heat-shielding covering with the necessary mass and thermophysical characteristics was one of the most acute problems both in our country and in the United States in construction of the Space Shuttle. The total mass of the thermal shielding of the "Buran" ship at the present time is less than 9 tons.

Another highly important problem was development of the technology for applying the covering. For a flightcraft of such a type a rigorous maintenance of aerodynamic configuration is very important. The adopted design of the thermal shielding provides for the installation of a total of about 39 000 "tiles" fabricated on lathes under specially formulated programs, taking into account the specific place of their installation on the body, with strict adherence to the gaps and rigorous limitations on the height of projections, being fractions of millimeters, ensuring stipulated theoretical contours.

Having a relatively high lift-drag ratio, the "Buran" ship is capable of a controllable descent in the atmosphere with the performance of a lateral maneuver along the descent trajectory up to 2000 km. This is a very important property, which in the case of appearance of unforeseen circumstances in the course of the flight makes it possible to scrub the flight and make a landing at one of the three airports in virtually all cases in the time allocated for this purpose.

In the "Buran" ship there are more than fifty systems linked in a single on-board control complex. Absolutely all the operations for control of on-board systems are performed automatically using the programs incorporated in the on-board computer. In the course of computer operation a thorough diagnosis of on-board systems is made and in case of necessity reserve sets of apparatus are automatically cut in.

A highly important property of the ship is its considerable load-lifting capacity. Its load compartment, with respect to both mass and size, makes it possible to hold, for example, the base module of such a station as the "Mir" or the operational "Kvant" module.

Despite its impressive size, the "Buran" ship has good maneuverability in orbit. The ship carries a combined engine operating on high-energy fuel components (oxygen-hydrocarbon fuel) for putting the vehicle into a working orbit, for interorbital transfers, for precise maneuvers near serviced orbital complexes, for orientation and stabilization. The engine is constructed in the form of a single assembly (base module) situated in the tail compartment of the body and two "belts" of engines near the front part of the body, in front of the cabin and in the rear part of the tail compartment. All engines are fed from unified fuel tanks. The total fuel supply is about 14 tons.

The "Buran" ship made its first flight without a crew aboard. This flight confirmed that the ship could perform flights up to and including landing in an automatic mode. The duration of the first flight of the "Buran" ship was only 205 minutes, that is, it executed not much more than two revolutions around the Earth, although the maximal duration of its autonomous flight (independently of orbital complexes) in the first stage can be up to seven days and in the second stage up to 30 days.

The segment of launching with the booster rocket has a duration of about 8 minutes and ends with the ship's separation from the central module (second stage) of the booster rocket. This segment is the most stressedwith respect to the dynamic loads on the ship caused by

aerodynamic forces and the acoustical effect. A special feature of the ballistic flight scheme is that the "Energiya" booster rocket does not put the ship into orbit but completes the active segment by creation of conditions for the realization of entry of the ship into orbit by the ship's own means and at the same time, conditions for sinking of the central module of the booster rocket into the waters of the Pacific Ocean. Altitude above the Earth at the time of the ship's separation is about 150 km.

In the segment of final insertion into orbit the ship's combined engine is fired twice. The total time of operation of the ship's service propulsion engines is about 100 seconds in the course of 45 minutes of flight, after which the ship enters a so-called circular reference orbit. The altitude of the reference orbit is 250 km.

During descent ship motion is controlled with the performance of a lateral maneuver ensuring conditions for the ship to enter into the zone of airport landing, prelanding maneuvering, reduction of the ship to the landing zone, flight in a glide and landing. In this segment there is rigorous control of the current velocity of the ship after active braking in the dense layers of the atmosphere, which should be adequate for reaching the airport. A special feature of this segment is a considerable flight time of the ship (about 20 minutes) in plasma without any possibility of radio exchange with surface control and monitoring facilities. After departure from plasma from an altitude of approximately 40 km and with a distance from the landing zone of 40 km control is accomplished by the interaction of on-board systems with surface airport facilities. In a case if after emergence from plasma the velocity exceeds the stipulated level the ship performs complex trajectory maneuvers for the purpose of reduction to the airport zone at a rigorously regulated velocity.

Preparations for the ship's first flight under the two-revolution program required an enormous number of tests. A full-size mockup of the ship was constructed and was used in carrying out strength, heat, acoustic, electric, horizontal flight and engine firing tests. The many kinds of technological equipment participating in preparations for the flight ship were checked.

Particular attention was devoted to the debugging of the automatic landing regime. Many tens of flights of a specially constructed full-size mockup of the ship were carried out for this purpose. The work was done on numerous simulation stands, as well as on flying laboratories based on TU-154 and TU-134 aircraft.

Much attention was devoted to debugging of the heat insulating covering. In particular, launchings of a special model of the ship into a suborbital trajectory were carried out.

The "Energiya"-"Buran" rocket-space system is a highly complex technical complex functioning under severe conditions, and like any complex technical system cannot be absolutely accident-free. Accordingly, in each launching the problem of the reliability of the complex and diagnosis of the systems is of particular importance in order to reduce risk to a minimum.

A convincing confirmation of this was the example of the scrubbed launching of 29 October, when, it would seem, provision had been made for everything and the preparations had proceeded amazingly smoothly. However, 51 seconds prior to the launching, in conformity to the requirements for very careful monitoring of all processes preceding the launching imposed on the automatic systems, the computer complex registered a lag in withdrawal of instrument complexes of the azimuthal orientation systems from the "Energiya" booster rocket and fed a command barring execution of the launching. The absence of such monitoring can lead to serious consequences.

In developing this complex there was adherence to the basic principle, already long applied in space technology, of stability of systems with two failures, which means: one failure—implementation of the program, two failures—safety and rescue of the crew. For this purpose multiple backups were used in a number of the most vitally important systems. Particular attention was devoted to the reliability of all, without exception, structural elements, assemblies, components and instruments in the course of experimental debugging under conditions known to be more severe than actually prevailing in space.

Also adopted was such a fundamental technical solution as the implementation of controlled flight of the booster rocket in the event of failure of one of the service propulsion engines of the first or second stage. Such a solution makes it possible automatically, depending on the time of appearance of engine failure, to put the ship into a low orbit or into a single-revolution flight trajectory with subsequent landing at an airport or execution of a return maneuver in which the booster rocket with the ship performs a flight in a "loop," optimal for each case, with rising to an altitude of 100 km with a distance from the launching site up to 500 km, with subsequent return to the launching region at an altitude of about 60 km and with a distance from the landing zone 200-300 km. At the end of the return maneuver conditions are formed for separation of the ship from the booster rocket, ensuring arrival of the ship in the landing zone. The "Buran" ship is intended for manned flight and even today everything is being done to make the risk minimal. It is necessary to think through the results of the just-completed flight and to carry out careful defectoscopy of all structural elements and onboard systems. Still broader tests of the ship are planned prior to the launching of a crew in order to be completely convinced of flight safety in this complex.

The just completed flight of the "Energiya" booster rocket with the reusable "Buran" ship can rightfully be classed as an outstanding scientific-engineering and production achievement of numerous teams in design bureaus, factories, institutes and construction organizations, all those who developed, constructed and tested the unique rocket-space system, all those who planned and built the highly complex technical, launching and landing complexes ensuring preparations for and implementation of this flight. Without question, this work, in which many hundreds of teams of different ministries and departments participated, once again has demonstrated the level of the scientific-technical capability of our Motherland to the entire world.

'Buran' Space Shuttle Described by Engineer

AU0401165889 Sofia RABOTNICHESKO DELO in Bulgarian 3 Jan 89 p 5

[Report on "Buran" space shuttle, including interview with Engineer Aleksandr Nikitin in Baykonur, by RABOTNICHESKO DELO correspondent Atanas Atanasov: "Forefather of the Generation of Soviet Space Shuttles"—date of interview not given]

[Excerpts] Baykonur, Moscow (from RABOTNICHESKO DELO correspondent Atanas Atanasov)—The building is located in Baykonur. I found myself there thanks to the growing openness and glasnost, which is reducing more and more the numbers of "closed" zones on Soviet territory. As for Baykonur—the launching site for piloted spacecraft and interplanetary stations, foreign journalists have visited it for a long time on two sorts of occasion. First, when spaceships with international crews are launched from there, and second, when these ships land in the Kazakhstan steppe after completing their missions.

...From the outside, the building reveals nothing about its special purpose. From the viewpoint of size and architecture, it lies between an administrative building and an industrial plant. However, when one is inside, its spaciousness in both vertical and horizontal directions is truly impresaive. Its total area is 72,000 square meters. Artificial lighting and special air conditioning installations create an environment in which you have the feeling of being in bright sunlight in the open air. Everyone wears white overalls. Four "Buran" shuttles—two prototypes and two being assembled—stand in the four separate sections of the building. [passage omitted]

[Atanasov] What aspect of the technical specifications of this spacecraft represents a qualitatively new contribution by scientists, designers, and engineers?

"Naturally, 'Buran's' electronic brain," Engineer Aleksandr Nikitin immediately replied. "Its high content of the latest electronic and automated equipment enables it, after two orbits in space, to assume the functions of a jet aircraft and make an automatic landing with incredible accuracy on a specially constructed runway in Baykonur. Please note that this is the world's first pilotless landing of a 'space shuttle' returning from its flight."

The space shuttle's heat-insulating "chain armor" is a supreme achievement in its design, Engineer Nikitin explained. On its return flight from space, the huge "Buran" craft passes through a "plasma fire" created by its high velocity and atmospheric friction that causes its temperature to rise to over 1500 degrees, which no metal can withstand. The scientists and engineers have discovered the required type of alloy, which is unlike anything previously used in world practice.

The material used consists of comparatively light tiles, reminiscent of foam plastic. Almost 2 years of research and experiments were needed to develop the reliable technology for determining the geometry of the tiles and for securing them in place with adhesive, to conform to the aerodynamic surface of the craft. Another curious fact is that the shape of each of the 38,000 tiles and the accuracy with which they were fixed in place have been determined and verified by computer, in accordance with their performance specifications, as soon as they appeared in the computer program. [passage omitted]

[Atanasov] What are the possibilities for using the advanced scientific and technical projects developed for space purposes in the various fields of the economy?

"The opportunities are immense and inexhaustible," the Soviet scientist replied. "Their use in the country's everyday life can bring billions of rubles in income, far exceeding the expenditure on space research.

"For example, the unique independent miniature computer for controlling the space shuttle [kosmolet] can be used in civil aviation, nuclear engineering, and so on. The experience in this sphere, gained by experiment and tested in practice, can be applied not only in the engineering branches. As a matter of fact, the majority of the space technologies, equipment, computer programs, materials, etc., are suitable for mass use to great economic effect in all spheres of the economy. The potential gain from such costly experiments as 'Energiya—Buran' is obtained precisely from utilizing these possibilities."

Soviet-Bulgarian Mission To 'MIR'

Main and Backup Crews for Soviet-Bulgarian Mission

18660019a Moscow IZVESTIYA in Russian 21 May 88 p 2

[TASS Report]

[Text] Star City (Moscow Oblast), 20 May. Only two weeks are left until the beginning of the second Soviet-Bulgarian space mission. The scheduled time for launching the spaceship "Soyuz TM-5" on 7 June is 1805 hours Moscow time.

This was announced to journalists by General-Major of Aviation A. Leonov, deputy head of the Cosmonaut Training Center. He introduced the crews which are to fly to the Baykonur Cosmodrome within the next few days. They will begin pre-launch training at the cosmodrome.

The first crew consists of Lieutenant-Colonel Anatoliy Solovyev, the commander; pilot-cosmonaut of the USSR Viktor Savinykh, the flight engineer; and Major Aleksandr Aleksandrov, cosmonaut-researcher and a citizen of the People's Republic of Bulgaria. Aleksandrov was Georgiy Ivanov's back-up man in 1979. The second crew is headed by Colonel Vladimir Lyakhov, pilot-cosmonaut of the USSR; the flight engineer is pilot-cosmonaut of the USSR Aleksandr Serebrov, and the cosmonaut-researcher is Senior Lieutenant Krasimir Stoyanov.

During a 10-day expedition to the "Mir" station, a Soviet-Bulgarian crew is to perform 40 experiments in the fields of remote sensing of the Earth, materials science, medicine and astrophysics.

Flight Coordinating Center in Bulgaria

18660019b Moscow VECHERNYAYA MOSKVA in Russian 7 Jun 88 p 1

[Article by I. Petrov]

[Excerpt] The second Soviet-Bulgarian crew sets out on a space mission from the Baykonur Cosmodrome today.

This crew consists of Soviet cosmonauts A. Solovyev and V. Savinykh and a Bulgarian cosmonaut, A. Aleksandrov.

Here is one more item of news: a kind of sister-organization of the Flight Control Center in suburban Moscow has been created for the first time in Bulgaria. It is the International Coordinating Center in the city of Stara Zagora. The two centers are now linked by a direct audiovisual channel, through which information on the mission's progress will be received.

Plans call for the mission to last 10 days.

Unsuccessful First Soviet-Bulgarian Mission in 'Soyuz-33' Recalled

18660019c Moscow TRUD in Russian 8 Jun 88 pp 5,6

[Article by V. Golovachev]

[Abstract] The article records conversations between journalists and the Soviet-Bulgarian crew which was to take part in experiments on board the orbiting complex "Mir." This conversation took place shortly before the crew departed for the Baykonur Cosmodrome. The cost and profitability of space missions was one of the topics. It was noted, for example, that a space mission of a Soviet cosmonaut costs 5 to 5.5 million rubles, on the average, while a mission of a foreign cosmonaut is twice as expensive. The research program of the upcoming mission was compared with that of the crew of the spaceship "Soyuz-33," which was launched in April of 1979. Soviet cosmonaut N. Rukavishnikov and Bulgaria's Georgiy Ivanov were the members of this crew.

Events of the 1979 mission are recounted in some detail. When "Soyuz-33" was 4 kilometers from the orbiting station "Salyut-6," it is recalled, Rukavishnikov and Ivanov received permission to fire the spaceship's main (rendezvousing-correcting) engine, which had functioned normally six times. This time, the engine, which was supposed to operate for six seconds, cut off unexpectedly after three seconds, together with the ship's "Igla" system for controlling rendezvousing and docking. Another attempt to activate the engine was unsuccessful. The crew of "Salyut-6"—cosmonauts V. Lyakhov and V. Ryumin—saw flames spurting sideways from the engine, in the direction of the spaceship's back-up engine.

Among the alternative solutions which were considered was one variant which called for firing the spaceship's low-thrust braking engines. It was thought that they might have enough reserve fuel to put "Soyuz-33" into a lower orbit, where the ship would gradually slow down and go into a descent from the effect of the Earth's atmosphere. The ship's oxygen reserve, which was sufficient for less than four days, might not last until the descent began, however. A second variant called for the crew of "Salyut-6" to approach "Soyuz-33" and attempt to dock with it, using the station's engines. The decision was finally made to attempt a landing with the aid of the spaceship's reserve engine, which would have to operate for 188 seconds. If it operated for less than 90, or without full thrust, the crew would be stranded permanently in orbit. The engine was fired successfully, but failed to cut off automatically at the specified time. Not knowing the thrust of the engine, Rukavishnikov quickly made the decision to let it run an additional 25 seconds, then cut it off manually. This would put the spaceship into a ballistic descent with g-loads 2.5 times the usual ones (8 to 10 g's), but the ship's return to Earth would be ensured.

It is recalled that improvements were made in the engines of transport spaceships after this flight. Lyakhov and Ryumin returned to Earth in a spaceship, "Soyuz-34," which was equipped with a new engine.

'Soyuz TM-5' Docks at "MIR' Complex

18660019d Moscow IZVESTIYA in Russian
11 Jun 88 p 1

[TASS Report]

[Text] The spaceship "Soyuz TM-5" docked with the scientific research complex "Mir" on 9 June 1988, at 1957 hours Moscow time.

An international crew—Soviet cosmonauts Vladimir Titov, Musa Manarov, Anatoliy Solovyev and Viktor Savinykh and Bulgarian cosmonaut Aleksandr Aleksandrov—has begun carrying out a program of joint research and experiments in near-Earth orbit.

The mission's research program, which was prepared by scientists of the Soviet Union and Bulgaria, is scheduled to last eight days.

The international crew is to carry out an extensive program of astrophysical research and photograph the Earth's surface, including territory of the People's Republic of Bulgaria. Also planned are medical-biological studies and space materials-science experiments. A substantial portion of the joint work will be performed with the aid of scientific equipment which was developed by Bulgarian specialists and delivered into orbit by the cargo spaceship "Progress-36."

The onboard systems of the orbiting complex "Mir" are functioning normally.

Comrades Titov, Manarov, Solovyev, Savinykh and Aleksandrov are feeling well.

Cosmonauts Begin Experiment Programs

18660019e Moscow PRAVDA in Russian 11 Jun 88 p 1

[TASS Report]

[Text] Flight Control Center, 10 June. The international crew consisting of Vladimir Titov, Musa Manarov, Anatoliy Solovyev, Viktor Savinykh and Bulgarian cosmonaut Aleksandr Aleksandrov is working for the second day in near-Earth orbit.

The scientific program of the joint work on board the "Mir" complex is packed with diverse studies. Today's program includes astrophysical and geophysical studies and medical, technological and biotechnological experiments, in particular.

A substantial place in the work of the Soviet-Bulgarian crew is reserved for extra-atmospheric astronomy research employing an astrophysical complex, "Rozhen." The cosmonauts will calibrate and tune equipment today. The constellations Ophiuchus and Cygnus have been selected as standard radiation sources for this purpose.

The day's agenda calls also for a series of photographing and spectrometry of Bulgarian territory, measurement of optical characteristics of the atmosphere, and a technological experiment, "Kliment-Rubidiy," in the "Kristallizator" unit.

In addition to the Soviet-Bulgarian studies, a biotechnology experiment begins today on board the orbiting complex "Mir." This experiment is being conducted in line with an agreement between the Soviet Union and Australia. The purpose of the experiment is to obtain single crystals of an influenza-virus antigen in conditions of zero gravity, so that studies of the three-dimensional structure and properties of these crystals can subsequently be made.

In the course of the day, the cosmonauts exchanged personal equipment in the transport spaceships, since Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov will return to Earth in "Soyuz TM-4."

According to telemetry data and reports from the crew, the flight is proceeding normally.

The crew of the visiting expedition underwent a medical examination for the purpose of further studying features of the human organism's adaptation to conditions of zero gravity.

All five cosmonauts are feeling well.

Cosmonauts Perform Remote Sensing, Astronomy, Materials Studies

18660019f Moscow IZVESTIYA in Russian
12 Jun 88 p 1

[TASS Report]

[Text] Flight Control Center, 11 June. The work day of the Soviet-Bulgarian crew on board the "Mir" complex began at 0900 hours Moscow time, and will last until midnight.

In line with the program of geophysical studies, the cosmonauts are conducting the latest series of "Georesurs" experiments today. The purpose of these experiments is to photograph individual sections of the Earth's surface, study optical characteristics of the atmosphere and record various components of atmospheric pollution. This work is being performed with the aid of the stationary camera KATE-140, hand-held cameras and the apparatus "Spektr-256."

Extra-atmospheric astronomy research employing the astrophysical complex "Rozhen" is continuing. The constellations Pegasus, Sagittarius and Ophiuchus have been

selected as the objects of these observations. The "Rozhen" apparatus includes an optoelectronic converter with a cooled receiver, a computer for processing results of measurements and controlling experiments automatically, and a system for recording information.

The latest "Kliment-Rubidiy" experiment in the field of space materials science will be conducted in the course of the day. The purpose of this experiment is to perfect a process for obtaining unique materials with high ion conductivity.

A series of biotechnology experiments with the "Aynur" and "Ruchey" units is being conducted on board the complex in line with a Soviet research program. The first of these experiments is intended for obtaining single crystals of protein preparations in conditions of zero gravity, so that studies of the three-dimensional structure and properties of these crystals can subsequently be made. Interferon obtained by genetic engineering is purified electrophoretically in the second experiment.

A Sofia-space television link was organized on the evening of 10 June. In a conversation with the international crew which took place during a period of television communication, comrade Todor Zhikov, general secretary of the Central Committee of the Bulgarian Communist Party and chairman of the State Council of the People's Republic of Bulgaria, wished the cosmonauts a successful completion of their mission program.

According to results of medical monitoring, the condition of the health of Vladimir Titov, Musa Manarov, Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov is good.

The program of the joint flight is being carried out successfully.

'Spektr-256' Multispectral Apparatus

18660019g Moscow IZVESTIYA in Russian 12 Jun 88 p 2

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] At the Baykonur Cosmodrome, Professor B. Bonev, director of the Bulgarian Academy of Sciences' Institute of Space Research, told journalists that the "Shipka" program has cost 7 million leva. This program not only includes scientific and technical experiments which are aimed at acquiring new knowledge and prepares technological resources but is of great economic importance even now.

An instrument called "Spektr-256" was developed under the direction of Professor D. Mishev at the Bulgarian space-research institute.

The number in the name of this instrument signifies that the cosmonauts can now record spectral characteristics of the Earth's surface in 256 channels, in visible and infrared radiation, instead of 15 channels, as was formerly the case. How much this increases the research capabilities of this apparatus becomes clear when one considers the fact that each channel records some characteristic feature of a natural formation.

It is important that recorded spectra be referred at once to localities that are being probed. A cosmonaut looks through the lenses of the "Spektr-256" and a camera simultaneously, recording on film the locality that is being observed. If the object of observation is uniform, the data from the strip of Earth 120-150 meters wide which is being studied with the "Spektr-256" can be extended to the entire locality. This increases the instrument's value. A Bulgarian microcomputer with a floppy-disk memory is used to record information. The Soviet-Bulgarian crew will bring the disks back to Earth.

No instrument similar to the "Spektr-256" exists in world practice.

"Our main objective is to study specially selected survey areas on Bulgarian and Soviet territory where observations will be conducted simultaneously from airplanes and on the ground," said D. Mishev. "This work is of both scientific and much economic importance, for geology, agriculture and forestry. Not only dry land but the coastal shelf and the Black Sea itself will be studied."

The Earth and the universe are studied through windows of "Mir" and "Kvant." The manner in which optical characteristics of these windows change in the course of time will also be studied in detail with the aid of "Spektr-256." This is very important for the purpose of eliminating distortions brought about by bombardment of the panes with micrometeorites and flows of charged particles.

Having found breaks in the cloud cover, the Soviet-Bulgarian crew began an experiment called "Georesurs-1" after their midday meal on 10 June. The "Spektr-256" apparatus and the Soviet camera "KATE-140" were used in this experiment.

Crystal Growth, Influenza Virus Experiments

18660019h Moscow SOVETSKAYA ROSSIYA in Russian 14 Jun 88 p 3

[Article by Aleksandr Nemov, special correspondent at the Flight Control Center]

[Abstract] The article records conversations with specialists at the Flight Control Center and the Soviet-Bulgarian crew of the orbiting complex "Mir." They commented on the nature and prospective applications of medical-biological and crystal-growing experiments which the cosmonauts were conducting.

Candidate of Physical-Mathematical Sciences I. Videnskiy, a science associate of the USSR Academy of Sciences' Institute of Space Research, is quoted in regard to a series of experiments called "Kliment-Rubidiy" which was being conducted in an automated unit, "Kristallizator," on board the "Mir" complex. The purpose of these experiments is to obtain high-quality rubidium-silver iodide single crystals. These experiments are performed at times when the crew of "Mir" is resting or sleeping, in order to reduce effects of extremely small gravitation caused by the cosmonauts' movements and ensure an adequate power supply for research equipment. Since the "Kliment-Rubidiy" experiments consume a considerable amount of power, they must be conducted at times when other equipment of the complex is not in operation, Videnskiy explained. Results of the experiments are expected to find use in development of compact and reliable storage cells and capacitors for electric motor vehicles, for example.

Candidate of Medical Sciences A. Lepskiy, an associate of the USSR Main Administration for Developmnent and Use of Space Technology for the Economy and Scientific Research, commented on biotechnology experiments which were first proposed by an Australian scientist. These experiments were begun by the Soviet-Bulgarian crew and are to be completed in two months by a Soviet-Afghan crew on board "Mir." The purpose of the experiments is to obtain a homogeneous crystal of a membrane protein of the influenza virus. Scientists hope to obtain a crystal whose atomic structure can be determined by means of x-ray analysis, Lepskiy explained. A crystal large enough for this purpose can be grown in space conditions, but this process takes more than two months. If the experiment is successful, its results can be used in creating an artificial counterpart of the membrane protein and developing an influenza vaccine. Lepskiy mentioned plans for performing similar research for American companies on a commercial basis, beginning next year.

Studies of Ionosphere and Atmosphere, Cosmonauts' Adaptation

18660019i Moscow PRAVDA in Russian 13 Jun 88 p 1

[TASS Report]

[Excerpt] Flight Control Center, 12 June. Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov are conducting research for the fourth day with Vladimir Titov and Musa Manarov on board the orbiting complex "Mir."

Today the cosmonauts are conducting a series of studies of physical processes occurring in the ionosphere and the upper layers of the atmosphere, using an optoelectric spectrophotometer, "Paralaks-Zagorka," which was developed by Bulgarian specialists.

Study of features of processes of adaptation of the human organism to conditions of space flight is one of the directions of the Soviet-Bulgarian research program. The crew of the visiting expedition is performing a set of medical experiments for this purpose. The working fitness of cosmonauts is studied and the effectiveness of means of preventing adverse effects of weightlessness evaluated in the course of these experiments.

A substantial place is reserved for geophysical experiments in the international crew's mission program. The cosmonauts are conducting the latest series of photographing and spectrometry of territory of the People's Republic of Bulgaria today. Information which is obtained will be used for accomplishing many scientific and economic tasks, including ones in the interest of geology and monitoring pollution of the atmosphere and coastal waters.

In line with the program of biological research, experiments are being continued which are aimed at studying the developmnent of higher plants in conditions of space flight. Seed wheat, arabidopsis tissue cultures and ginseng have been selected as objects of research.

The flight of the orbiting complex "Mir" is proceeding normally.

All of the cosmonauts are healthy and working in good spirits.

Sleep Research, Interferon Production, Astrophysical Studies

18660019j Moscow IZVESTIYA in Russian 14 Jun 88 p 1

[TASS Report]

[Text] Flight Control Center, 13 June. Cosmonauts Vladimir Titov, Musa Manarov, Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov are continuing joint work on board the orbiting complex "Mir."

The crew of the visiting expedition has performed a considerable amount of medical research. One of the tasks of this research has been to determine the relationship between the working fitness of cosmonauts and the adequacy of their sleep and rest, in particular. Aleksandr Aleksandrov conducted an experiment during which the quality of sleep was determined in accordance with electrophysiologic indicators recorded by an apparatus called "Son-3" (sleep-3) and replies to a questionnaire.

The latest lot of interferon obtained by genetic engineering has been purified electrophoretically in the "Ruchey" unit.

In line with the program for research of Earth natural resources and study of the environment, the cosmonauts will perform several series of photographing and spectrometry of individual sections of the Earth's surface today.

Research employing the "Rozhen" apparatus is continuing. Experiments are planned for the purpose of measuring background luminescence of the night sky and evaluating polarization of the radiation of astrophysical objects.

An experiment aimed at studying the development in zero gravity of higher plants exposed to a non-uniform artificial magnetic field has begun in the "Magnitogravistat" unit.

On the day's program is an onboard press conference of the international crew for Soviet and foreign journalists who are covering this space mission.

According to telemetry data and reports from orbit, the flight of the scientific research complex "Mir" is proceeding normally.

Comrades Titov, Manarov, Solovyev, Savinykh and Aleksandrov are feeling well.

Studies of Cosmonaut's Sleep, Ionizing Radiation on 'MIR'

18660019k Moscow IZVESTIYA in Russian
14 Jun 88 p 1

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] The idea was that Vladimir Titov and Musa Manarov would rest on Sunday; instead of doing so, however, they helped the visiting crew conduct Soviet-Bulgarian experiments which have now been launched in a wide range of fields in orbit. "Leisure" is planned on board the station, but this is merely the name of an experiment in which the effect of music, video information and games on the psychological state and working fitness of the crew is evaluated.

For Aleksandr Aleksandrov, even sleep is work. When he sleeps, an experiment called "Cosmonaut's Sleep" is in progress.

At a meeting in Sofia, Anna Varbanova, director of the Bulgarian Academy of Sciences' Institute for Study of the Brain and head of the group that authored this experiment, told me: "Sleep is a continuation of the waking state. If a person develops some kind of disorder, it will be reflected in his sleep. In collaboration with the Institute of Medical-Biological Problems, we have studied the sleep of Soviet aquanauts living in an underwater 'dwelling.' Sleep was found to be one of a number of highly sensitive indicators of a person's condition. The character of a person's sleep is reflected in his working fitness. We therefore have now decided to study the sleep of human beings in space living quarters. This will yield very interesting results, in our opinion. We hope to learn how to correct sleep so that for cosmonauts, it will not be superficial sleep but the deep kind which produces a full measure of rest. Equipment which has been designed and methods which have been developed for this experiment will be useful also for terrestrial research in cases of various illnesses."

The experiment was conducted for the first time on the night from Saturday to Sunday, and Aleksandrov will have to share secrets of his sleep two more times in the course of the mission. Such studies were conducted before the mission and will be continued after the cosmonauts land, so that scientists will obtain material for a comparative analysis.

Ionizing radiation, a constant factor of exposure to space conditions, is receiving much attention during the Soviet-Bulgarian mission. The goal has been set of studying radiation conditions in every nook and cranny of the station and observing the manner in which these conditions change along the route of the flight. A highly sensitive portable radiometer, "Lyulin," which was developed by Bulgarian specialists, is the primary instrument that is being used for this purpose, and an experiment called "Doza-B" is being conducted in addition. Detectors of ionizing radiation and specimens of biological materials that are sensitive to radiation have now been placed in various spots in the station's rooms. These specimens will be exposed to radiation throughout the mission, and the visiting crew will then bring them to Earth for analysis.

Scientists will be able to evaluate the protective action of the structure of "Mir," which is different at different points of the station. Preventive measures for future missions will be formulated with the aid of data that are obtained.

The color of various objects on the Earth's surface, including ones in the world's oceans, used to be determined visually by cosmonauts, with the aid of an onboard atlas of 1,000 colors.

During the present mission, data gathered by cosmonauts will be compared with data provided by an objective, impartial Bulgarian instrument, the "Spektr-256." After the mission is over, scientists will be able to ascertain the precise amount by which the cosmonauts' eyes were in error.

'Pleven-87' Unit for Study of Cosmonauts' Psychophysiological Reactions

18660019l Moscow IZVESTIYA in Russian
15 Jun 88 p 3

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] An echo of the battle [of Pleven in 1877] can be heard today in the joint Soviet-Bulgarian space mission. An experiment called "Pleven-87" has become an important part of the "Shipka" program.

An apparatus called "Pleven-87" was displayed at the Flight Control Center. It is a very compact instrument, smaller than a portable typewriter. The top of this apparatus opens while it is in operation, and the screen of a video display is found on its inner side. On the uncovered surface is a keyboard which is connected to a microprocessor inside the unit.

Candidate of Technical Sciences Petr Getsov, one of the heads of the "Shipka" project, told us: "The whole 'Pleven-87' instrument weighs 3 kilograms. It is programmed for 15 tests, which are used to study cosmonauts' psychophysiological reactions in conditions of a mission and compare them with data obtained on Earth, at times when research involves no stress situations."

Changes in memory over the course of the mission are being studied. Various shapes are shown on the screen, two of them in the instructional mode; the cosmonaut must memorize these shapes. When they appear among others, a button must be pressed.

Although the "Pleven" is a space instrument, it may prove useful also in terrestrial practice. It will allow data on an operator's psychophysiological condition to be obtained quickly and effectively. The "Pleven" is already being used to monitor the condition of Bulgarian pilots.

G. Radkovskiy, deputy director of the program of medical-biological experiments of the "Shipka" program, told us in Sofia: "All of these experiments have a common purpose—to study the working fitness of cosmonauts during a short mission of 10 days. This precisely is the period of adaptation, when human beings get accustomed to weightlessness. Rearrangements are in progress in the organism during this period, and intensive work must be done at the same time. We have tried to select experiments so that we can observe changes which occur on different structural levels of the human organism."

Study of Cosmonauts' Motor Functions, Radiation Conditions on 'MIR' Complex

18660019m Moscow IZVESTIYA in Russian
15 Jun 88 p 1

[TASS Report]

[Text] Flight Control Center, 14 June. The mission of the international crew consisting of Vladimir Titov, Musa Manarov, Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov is continuing on board the orbiting complex "Mir."

In line with the plan of joint work, medical-biological, technological, geophysical and astrophysical experiments are planned for today.

A program of medical research which Soviet and Bulgarian specialists prepared is drafted with consideration for the nature of space flight and the importance that is now attached to man-machine interaction.

The crew is conducting a series of experiments called "Potentsial" for the purpose of studying features of the condition of the human locomotor system in zero gravity. Results which are obtained will help to select optimal physical-conditioning regimens which promote maintenance of cosmonauts' working fitness on a high level, in particular.

An experiment called "Prognoz" (forecast) has been performed with the aid of the "Pleven-87" apparatus, for the purpose of evaluating the performance of operators' functions by cosmonauts.

Experiments for evaluating radiation conditions along the flight route of the complex and in its compartments are conducted daily with the aid of a highly sensitive radiometer, "Lyulin." In line with the biotechnology research program, one more lot of preparations of biologically active substances has been purified electrophoretically in the "Ruchey" unit.

The cosmonauts have performed a second "Kliment-Rubidiy" experiment for the purpose of perfecting a process for obtaining materials with high ion conductivity.

One more series of photographing and spectrometry of Bulgarian territory will be performed today while the "Mir" complex is flying over Bulgaria.

An experiment called "Struktur" will begin in the "Kristallizator" unit in the evening. The purpose of this experiment is to study the effect of zero gravity on the microstructure of an aluminum-copper alloy with an addition of iron.

According to results of medical monitoring and reports from orbit, all of the cosmonauts are healthy and feeling well. The flight of the manned complex "Mir" is proceeding normally.

'Rozhen' Charge-Couple Imaging Instrument

18660019n Moscow IZVESTIYA in Russian
16 Jun 88 p 3

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] In the Soviet-Bulgarian space mission, the main experiment on the sunlit side of the orbit is "Georesurs," but it is "Rozhen" on the dark side.

The "Rozhen" experiment was conceived and realized by Sofia University's chair of astronomy and the Bulgarian Academy of Sciences' Institute of Space Research.

The astronomical equipment-complex "Rozhen" is a most modern instrument. Light from the universe enters the long-focus lens of this instrument and is then recorded not on photographic plates or film but on a so-called charge-coupled array, where it is converted into an electric signal and represented in digital form. This signal is then received by another unit of the complex for recording and processing with a compact, large-capacity personal computer, which enables the cosmonauts to control the experiment in real-time conditions.

On the screen of a display device, the cosmonaut conducting the experiment (all of the visiting crew's members have now worked as operators) sees a picture of the starry sky in the area of the universe which has been selected for study. The cosmonaut can correct the experiment in accordance with the picture he observes.

The stellar image is simultaneously transmitted to Earth via telemetry channels.

On every day of the Soviet-Bulgarian mission, the portions of two to three orbits which lie on the dark side of the Earth are reserved for research employing the "Rozhen" apparatus, including studies of objects which are inaccessible to observers on the ground.

The experiments which are being conducted are exploratory in character and are to provide a basis for development in Bulgaria of modern onboard telescopes of high quality for extra-atmospheric astronomy and geophysical research.

The "Rozhen" also performs space-physics research. A special attachment called "Parallaks-Zagorka" is placed over its lens for this purpose. This attachment was developed at the Bulgarian space-research institute's base observatory in the city of Stara Zagora. Certain wavelengths are singled out and amplified 1,000 times with the aid of the attachment. These selected wavelengths are associated with photochemical processes which occur in the upper layers of the atmosphere. This is very important for understanding the mechanism of sun-Earth ties.

Many of the Earth's inhabitants have admired the polar auroras. The primary and visiting crews are to study this phenomenon and other kinds of luminescence of the ionosphere and upper atmosphere, using the "Parallaks-Zagorka" instrument.

Materials, Geophysical, Psychological Studies

18660019o Moscow IZVESTIYA in Russian 16 Jun 88 p 1

[TASS Report]

[Text] Flight Control Center, 15 June. The Soviet-Bulgarian crew continues to carry out joint work successfully on board the orbiting complex "Mir."

In line with the space materials-science program, the experiment "Struktura" which began yesterday has been completed in the "Kristallizator" unit. Specimens of an aluminum-copper alloy with different iron contents have been obtained in the course of this experiment. These specimens will be delivered to Earth for the purpose of further studying crystallization processes and developing new technology for obtaining composite materials.

The program of geophysical studies calls for photographing individual areas of land surface and the waters of the world's oceans, and for a series of experiments aimed at determining optical and spectral characteristics of the Earth's atmosphere.

Experiments employing the Bulgarian astrophysical complex "Rozhen" are continuing. The cosmonauts are conducting observations of various clusters of stars and central areas of our galaxy today with the aid of this equipment.

Medical examinations are conducted regularly in the course of the mission. An experiment called "Dosug" (leisure) is scheduled for the evening hours. The purpose of this experiment is to evaluate the effect of various musical and video programs and computer games on the crew's working fitness and morale.

According to telemetry data and reports from orbit, the onboard systems of the manned complex "Mir" are functioning normally.

Cosmonauts Vladimir Titov, Musa Manarov, Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov are healthy and feeling well.

Biomedical Monitoring of Cosmonauts

18660019p Moscow PRAVDA in Russian 16 Jun 88 p 1

[Article by A. Tarasov, special correspondent at the Flight Control Center]

[Abstract] The article comments on extra-atmospheric astronomy and medical-biological, atmosphere and Earth studies which were being conducted on board the orbiting complex "Mir." Astrophysicists from Sofia University and the Bulgarian Academy of Sciences' Institute of Space Research and other Bulgarian specialists who were following these activities had been assigned a room of their own at the Flight Control Center. Pictures of celestial objects observed with the "Rozhen" unit on "Mir" were being transmitted via telemetry channels to the center and reproduced on the screen of a "Pravets" personal computer in this room.

The cosmonauts and medical personnel reportedly praised the performance of a number of items of onboard equipment, particularly the "Spektr" unit, an instrument called "Globus" and a computer called "Zora." A map of the Earth with the flight path of "Mir" traced on it was being displayed on the screen of the

"Globus." Rumen Nedkov is identified as the chief designer of the "Zora." This computer and neuromuscular-signal sensors are used in a highly complex space experiment called "Potentsial." Data from sensors attached to cosmonauts are received by the computer in the course of this experiment. Three streams of data are amplified and processed, and results of the experiment are presented in visual form, analyzed and stored with the aid of modules of "Zora." Angela Khristova, one of the Bulgarian specialists at the center, mentioned that a cargo spaceship would soon deliver spare disks for the "Terma" to the orbiting complex. The "Terma" is a high-speed pulsed photometer which can be connected to the "Zora." Use of the "Spektr" in observations of noctilucent clouds is mentioned. Viktor Savinykh called for this instrument to be switched on when such clouds were spotted from "Mir."

Cosmonauts Conduct Materials Experiments, Report Computer Disks Missing

18660019q Moscow IZVESTIYA in Russian 17 Jun 88 p 3

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] Three technological experiments—"Struktura," "VOAL" and "Kliment-Rubidiy"—are being conducted in line with the "Shipka" program.

A composite material which cannot be produced in terrestrial conditions is obtained in the "VOAL" experiment. This material is a tungsten-aluminum alloy which is lightweight and possesses good strength and wear resistance at the same time.

In the experiment "Kliment-Rubidiy," it is planned to compare crystals of a valuable rubidium compound obtained in space with one obtained in conditions on the ground.

The research program on board the "Mir" complex is being carried out successfully, on the whole. Its course has been marred only by the mysterious disappearance of floppy disks with programs for a personal computer, "Zora," which is intended for controlling certain medical experiments and processing data from them. The disks were stowed in the transport spaceship on Earth, but they cannot be found in space.

Crew Prepares for Return to Earth

18660019r Moscow PRAVDA in Russian 17 Jun 88 p 1

[TASS Report]

[Text] Flight Control Center, 16 June. Vladimir Titov and Musa Manarov, the cosmonauts of the primary expedition, and Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov, the visiting crew, are completing the program of joint work on board orbiting complex "Mir."

Today the cosmonauts are performing a number of medical-biological studies, and they will conduct two series of remote sensing of Bulgarian territory while the complex is flying over Bulgaria.

The final space materials-science experiment has been performed in the "Kristallizator" unit. This experiment was aimed at studying the possibility of obtaining, in conditions of extremely small gravitation, specimens of a tungsten-aluminum composite material with improved properties.

The "Biokristallizator" experiment for growing single crystals of protein preparations has been completed.

Preparations have begun for the descent of the spaceship "Soyuz TM-4" from orbit. Cosmonauts Solovyev, Savinykh and Aleksandrov will return to Earth in this ship tomorrow. The crew is moving flight documents, exposed motion-picture and photographic film in cassettes, tape recordings, and biological specimens in containers into the spaceship's reentry vehicle and stowing them there. Materials from research carried out in line with the program of the Soviet-Bulgarian mission and during Vladimir Titov's and Musa Manarov's prolonged work in orbit will be delivered to Earth.

According to the crew's reports and telemetry data, the flight is proceeding in accordance with the designated schedule. All of the cosmonauts are healthy and feeling well.

Cosmonauts Solovyev, Savinykh, and Aleksandrov Return to Earth in 'Soyuz TM-4'

18660019s Moscow PRAVDA in Russian 18 Jun 88 p 1

[TASS Report]

[Excerpt] The international crew consisting of Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov, a citizen of the People's Republic of Bulgaria, returned to Earth on 17 June 1988 at 1413 hours Moscow time, after completing joint work on board the scientific research complex "Mir." Vladimir Titov and Musa Manarov are continuing their prolonged mission in orbit.

The reentry vehicle of the spaceship "Soyuz TM-4" made a landing 202 kilometers southeast of the city of Dzhezkazgan.

Cosmonauts Solovyev, Savinykh and Aleksandrov are feeling well after the landing.

Planned studies and experiments which scientists of the Soviet Union and Bulgaria had jointly prepared were carried out in their entirety by the international crew in the course of its eight-day mission on board the orbiting complex "Mir." A substantial portion of this work was conducted with the aid of apparatus developed by Bulgarian specialists.

In the course of the mission, a multipurpose astrophysical complex was tried out and several series of experiments were performed for the purpose of studying galactic and extragalactic sources of radiation, the interplanetary medium, and physical processes taking place in the Earth's ionosphere and atmosphere.

Specimens of single crystals of metal alloys and composite materials with improved characteristics were obtained in line with the space materials-science program.

Vladimir Titov, Musa Manarov, Anatoliy Solovyev, Viktor Savinykh and Aleksandr Aleksandrov operated efficiently and on a high professional level at every stage of the joint work.

(A photograph is given showing the members of the Soviet-Bulgarian crew in their space suits and seated in chairs after the landing.)

Specialists Comment on Crew's Health, Radiation Studies

18660019t Moscow SOVETSKAYA ROSSIYA in Russian 18 Jun 88 p 2

[Article by Aleksandr Nemov, special correspondent at Flight Control Center]

[Excerpt] The Soviet-Bulgarian crew had to figure out what had become of a flexible magnetic disk on which a program for experiments called "Statokinetika" and "Labirint" was recorded. These studies were to help scientists evaluate more precisely effects of weightlessness on the human vestibular apparatus and motor system. But the magnetic disk with the recorded computer program had disappeared completely. And these experiments were never performed.

"The equipment with which this research was to be conducted will remain on board the 'Mir' station," said Candidate of Medical Sciences A. Lepskiy, science associate of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research. "A Soviet-Afghan crew will be launched in August. 'Labirint' and 'Statokinetika' will thus be included in their research program.

"The 'Mir' station's orbit lies below the Earth's radiation belts, which begin at an altitude of approximately 500 kilometers," related A. Lepskiy. "Solar and space radiation that reaches the station is already weakened. Even during prolonged missions, the levels of radiations to which cosmonauts are exposed consequently do not exceed the permissible norms and are approximately the same as in terrestrial laboratories where work is done with radioactive substances. Interplanetary missions are another matter. Spaceships will no longer be protected against streams of particles from solar flare-ups. Special radiation protection will be required. New studies are needed, considering the fact that a manned launch to Mars is now being discussed seriously. The experiment 'Doza-B' which was conducted during the international mission will help to study effects of radiation on various biological structures (the blood, etc.)."

Candidate of Medical Sciences O. Anashkin, head of the medical support group for the mission, related: "All three cosmonauts—A. Solovyev, V. Savinykh and A. Aleksandrov—adapted quickly to conditions of zero gravity.

"One of the crew said jokingly that their state of health was the result of an excellent selection of foodstuffs for the guests. There is a grain of truth in this; yogurt (a fermented-milk product) with oatmeal, wild-rose yogurt, melons, peaches and apples were included in their dietary rations."

"And V. Titov and M. Manarov, the primary crew—how are they doing? After all, they have been in orbit for half a year."

"They are carrying out all recommendations of medical personnel carefully, including physical exercises twice a day—one hour on the stationary bicycle and one on the running track.

"We think that no particular deviations have occurred in the crew. The commander's shin volume has decreased by 16 percent and the flight engineer's by 18 percent. Whereas V. Titov has become 1.6 kilograms thinner, M. Manarov has put on 2.7 kilograms."

FTD/SNAP

Soviet-Afghan Mission to 'Mir' Station

Launch of Soviet-Afghan Crew in 'Soyuz TM-6'

18660055a Moscow PRAVDA in Russian 30 Aug 88 p 1

[TASS Report]

[Text] The spaceship "Soyuz TM-6" was launched from the Soviet Union on 29 August 1988, at 0823 hours Moscow time.

The spaceship is manned by an international crew: pilot-cosmonaut of the USSR Vladimir Lyakhov, twice Hero of the Soviet Union and the commander; physician-researcher Valeriy Polyakov; and cosmonaut-researcher Abdul Ahad Mohmand, a citizen of the Republic of Afghanistan.

The program of the space mission calls for the "Soyuz TM-6" ship to dock with the manned complex "Mir" and for joint scientific research and experiments to be conducted on board the complex with cosmonauts Vladimir Titov and Musa Manarov, who have been working in near-Earth orbit since 21 December 1987.

The Soviet-Afghan space mission is being carried out in line with an agreement between the governments of the Union of Soviet Socialist Republics and the Republic of Afghanistan.

According to telemetry information, the onboard systems of the spaceship "Soyuz TM-6" are functioning normally.

Cosmonauts Lyakhov, Polyakov and Mohmand are feeling well.

Biosketches of Cosmonauts Lyakhov, Polyakov, Mohmand

18660055b Moscow PRAVDA in Russian 30 Aug 88 p 1

[Text] Pilot-cosmonaut of the USSR Vladimir Afanasyevich Lyakhov, twice Hero of the Soviet Union, was born on 20 July 1941, in the city of Antratsit, Voroshilovgrad Oblast.

After graduating from the Kharkov Higher Military Aviation School for Pilots imeni Gritsevets in 1964, he served in the Air Force. He has the qualifications "Military Pilot 1st Class" and "Test-Pilot 3rd Class."

V.A Lyakhov has been a member of the Communist Party of the Soviet Union since 1963.

Vladimir Afanasyevich was enrolled in the cosmonaut contingent in 1967.

In 1975, without leaving his work at the Cosmonaut Training Center, V.A. Lyakhov graduated from the Air Force Academy imeni Gagarin.

Vladimir Afanasyevich has carried out two space missions. The first, which lasted 175 days, was made in 1979 on the spaceship "Soyuz-32" and the orbiting station "Salyut-6," and the second, which lasted 150 days, was made in 1983 on the spaceship "Soyuz T-9" and the orbiting station "Salyut-7." The qualification "Cosmonaut 2nd Class" has been conferred upon him.

Valeriy Vladimirovich Polyakov was born in Tula on 27 April 1942.

He graduated from Moscow Medical Institute No. 1 imeni Sechenov in 1965. He subsequently worked at various scientific research institutes and organizations. He proved himself to be a competent and erudite specialist in the field of space medicine. He took part repeatedly in medical support of manned missions on "Soyuz" spaceships and "Salyut" orbiting stations. He is a candidate of medical sciences.

V.V. Polyakov has been a member of the Communist Party of the Soviet Union since 1970.

V.V. Polyakov has been employed at the Institute of Medical-Biological Problems of the USSR Ministry of Health since October of 1971.

Valeriy Vladimirovich began to train for space flights in 1972. He has passed a complete course of training for flights on "Soyuz TM" spaceships and the orbiting station "Mir," in the capacity of a physician-researcher.

Abdul Ahad Mohmand, a citizen of the Republic of Afghanistan, was born on 1 January 1959, in Sarda settlement, Shangar District, Ghazni Province. He is a Pashtoon by nationality.

After completing school, he enrolled in the Kabul Polytechnical Institute in 1976.

He was inducted into the army in 1978 and sent to the Soviet Union to receive a military education. After graduating from a military school for pilots, he served in Afghanistan's air force.

He continued his flight service after graduating from an air force academy in 1987.

In February of 1988, Abdul Ahad Mohmand began to train at the Cosmonaut Training Center imeni Gagarin for a joint Soviet-Afghan mission. He has passed a course of training for flights on "Soyuz TM" spaceships and the orbiting complex "Mir."

Crew's Resource, Medical Research Plans

18660055c Moscow PRAVDA in Russian 30 Aug 88 pp 1, 3

[Article by A. Pokrovskiy]

[Abstract] The article recounts meetings with Soviet and Afghan cosmonauts who had been training for the next international mission on board the orbiting complex "Mir." The meetings took place after a state commission had selected Vladimir Afanasyevich Lyakhov, Abdul Ahad Mohmand and Candidate of Medical Sciences Valeriy Vladimirovich Polyakov as the members of the primary crew for this mission.

Lyakhov mentioned that one of the Afghan trainees, Mohammad Dauran Gulyan Masum, had undergone an appendicitis operation during training. Although Lyakhov considered both of the Afghans equally fit for the upcoming mission, he thought that this event may have influenced the state commission's selection of Mohmand over Dauran as the Afghan member of the primary crew.

The Soviet-Afghan crew's planned research on board "Mir" is said to include work in line with a program called "Shamshad" (lotus) for study of natural resources of Afghanistan. This program is characterized as a natural continuation of the "Shipka" program which was conducted during the recent stay of a Soviet-Bulgarian crew on board "Mir." Soviet and Bulgarian instruments

developed for "Shipka" are to be used also during the upcoming mission. Medical experiments scheduled for performance during this mission reportedly include a study of processes of hematopoiesis in zero gravity. In connection with these experiments, it was proposed that a bone-marrow sample be taken from Polyakov himself before the mission began, for the purpose of comparing results. Polyakov's back-up, German Arzamazov, was to perform a substantial portion of the terrestrial work involved in the hematopoiesis study.

Cosmonaut-Physician Polyakov's Role on 'Mir' Station

18660055d Moscow IZVESTIYA in Russian 30 Aug 88 p 1, 2

[Article by B. Konovalov, special correspondent at the Baykonur Cosmodrome]

[Text] When physician Boris Yegorov took off into space, the thought which occurred immediately to Valeriy Polyakov was: "What if I were to?" Polyakov began finding out how one might get into the Institute of Medical-Biological Problems (IMBP), where work was being done on space topics. But many years passed before he succeeded in doing this.

Fate guided him to the USSR Ministry of Health, where he worked under the direction of N.N. Gurovskiy, an eminent Soviet specialist in the field of space medicine.

In 1972, Polyakov was officially enrolled in the cosmonaut contingent as a physician who could render any kind of assistance in orbit, including surgical assistance. A group of cosmonaut-physicians was organized at IMBP. Polyakov was appointed commander.

Polyakov's training course for the Soviet-Afghan mission was his third (not counting retraining). It costs about a million rubles to train a single cosmonaut belonging to a crew, according to an estimate made by General-Lieutenant V.A. Shatalov. But the state has invested at least 3 million in Polyakov.

Polyakov is taking off as a member of the Soviet-Afghan crew. He will help to carry out the whole joint program, in which medical experiments hold a position of key importance. Then he will say good-bye to V. Lyakhov and A. Mohmand and remain on board "Mir" together with V. Titov and M. Manarov, who have now been in space for more than 200 days. He will monitor the condition of these long-time occupants of the station. Later on, he will greet 'newcomers'—a Soviet-French crew—on board "Mir."

Polyakov's Medical Skills, Psychological Support Role Noted

18660055e Moscow KOMSOMOLSKAYA PRAVDA in Russian 30 Aug 88 p 1

[Article by Sergey Leskov, special correspondent at the Baykonur Cosmodrome]

[Excerpt] Western journalists came to Baykonur for the first time, for the launch of the Soviet-Afghan space crew. All kinds of questions were asked and all kinds of pictures were taken.

Physician Valeriy Polyakov will play the lead role in the medical portion of the joint research program. In line with this program, Polyakov is to remain on board the "Mir" complex with Titov and Manarov at least until the completion of their mission, which is supposed to be a record one. Polyakov is, incidentally, not only a qualified scientist but also an excellent clinical physician, related A. Grigoryev, director of the Institute of Medical-Biological Problems. He has knowledge not only of methods of conventional medicine but also of folk remedies and acupuncture zone therapy. And there is still another important circumstance. Titov and Manarov will need subtle psychological support, particularly during the final phase of their work. Polyakov is just the kind of person who is capable of performing this delicate task best of all, in the opinion of specialists.

'Soyuz TM-6' Docks With 'Mir' Complex

18660055f Moscow IZVESTIYA in Russian 1 Sep 88 p 1

[TASS Report]

[Text] The spaceship "Soyuz TM-6" docked with the scientific research complex "Mir" on 31 August 1988, at 0941 hours, Moscow time.

An international crew consisting of Soviet cosmonauts Vladimir Titov, Musa Manarov, Vladimir Lyakhov and Valeriy Polyakov and Afghan cosmonaut Abdul Ahad Mohmand has begun performing joint research and experiments.

The Soviet-Afghan crew's program of work on board the "Mir" complex is scheduled to last six days and includes geophysical and medical-biological studies.

The cosmonauts are to make a large number of visual and instrumental observations and photographs of territory of the Republic of Afghanistan in order to accomplish various tasks for this country's science and economy. It is planned in particular to photograph mountainous and hard-to reach areas of Afghanistan which are of interest for mineral prospecting, and also for the purpose of identifying lands which are suitable for development and evaluating seismic conditions of the territory.

One distinctive feature of medical-biological experiments which will be conducted in the course of the joint mission is that a physician-researcher will take part directly in them.

After the program of joint research is completed, Vladimir Lyakhov and Abdul Ahad Mohmand will return to Earth in the spaceship "Soyuz TM-5", and Vladimir Titov, Musa Manarov and Valeriy Polyakov will continue to work in near-Earth orbit.

According to results of radio conversations with the crew, the cosmonauts are feeling well.

The onboard systems and scientific equipment of the manned complex "Mir" are functioning normally.

Comments on Computerized Docking Procedure of 'Soyuz TM-6'

18660055g Moscow KRASNAYA ZVEZDA in Russian 1 Sep 88 p 3

[Article by Lt. Col. V. Baberdin, Flight Control Center]

[Text] All cosmonauts who are not busy and off-duty shift specialists who support flights usually gather at the Flight Control Center (TsUP) during a docking.

"The commander and flight engineer of a spaceship's crew used to experience tremendous physical and psychological stress when we began a docking operation," recalled Georgiy Grechko, pilot-cosmonaut of the USSR. "Everything is different now. The commander alone monitors instruments for docking; he has a personal computer which enables him to make the necessary corrections. The flight engineer and researcher play essentially the roles of passengers of the spaceship."

"The two-day routine for rendezvousing spacecraft which is currently accepted makes it possible to dock them at different positions in orbit," related Professor, Doctor of Technical Sciences V. Pochukayev, deputy flight director for ballistic support. "Stored in the onboard computer of 'Soyuz TM-6' is a gravitational model of the Earth—a system of differential equations with an enormous number of constants. Navigational mathematical filters ensure that the necessary commands pass and work is done in a completely automatic mode.

"Soyuz TM-6" and the "Mir" station were fairly distant from each other on 29 August, after the spaceship was launched. During the next two days, two powerful and prolonged pulses were executed, and the ship ascended sharply. Its orbit parameters were: maximum altitude—348 kilometers; minimum altitude—315 kilometers; period of revolution—91 minutes. The automatic system "Kurs" went into operation when the distance between the spacecraft had decreased to 40 kilometers. With the aid of powered gyroscope-gyrodynes, the "Mir" complex was then stabilized in a position that would ensure good illumination of the docking target by the sun.

Over the loudspeaker, we hard the spaceship's crew report "400 meters." "Soyuz TM-6" began to fly around "Mir." It then hovered at a distance of 150 meters from the station, opposite the station's docking mechanism, while specialists of TsUP evaluated the condition of the ship's onboard systems by means of telemetry. Permission was given to dock.

Cosmonauts Begin Resource Observations, Biomedical Research

18660055h Moscow PRAVDA in Russian 2 Sep 88 p 1

[TASS Report]

[Text] Flight Control Center, 1 September. The Soviet-Afghan crew's second day of work on board the "Mir" complex began at 0900 hours Moscow time, and will last until midnight.

Research in line with a program of experiments called "Shamshad" has been allotted a substantial place in the joint mission. These experiments include visual observations and photographing of territory of the Republic of Afghanistan. The cosmonauts are performing this work with the aid of the stationary camera KATE-140, handheld cameras, and the spectrometers MKS-M and "Spektr-256." Information that is obtained will be used in the interests of many branches of science and the country's economy—for prospecting oil, gas, other mineral resources and underground reserves of water, for example.

Further study of features of the human organism's adaptation to conditions of space flight is an important direction of the Soviet-Afghan research program. For this purpose, Vladimir Lyakhov, Valeriy Polyakov and Abdul Ahad Mohmand are performing a set of medical experiments in the course of which the cosmonauts' working fitness is studied and the effectiveness of means of preventing adverse effects of weightlessness is evaluated.

A series of biological experiments has begun which is aimed in particular at studying features of protein and calcium metabolism in higher plants and evaluating the stability of a complex ecological system, using aquarium fish and chlorella as an example.

Vladimir Titov and Musa Manarov began an experiment in the "Aynur" unit yesterday. The purpose of this experiment is to perfect a process for obtaining single crystals of protein preparations in conditions of extremely small gravitation. Today the cosmonauts will purify a consignment of interferon electrophoretically and made a number of measurements for the purpose of determining optical characteristics of the Earth's atmosphere.

In the course of the day, the cosmonauts are to exchange individual items of gear in the transport spaceships, since Vladimir Lyakhov and Abdul Ahad Mohmand will return to Earth in "Soyuz TM-5."

According to evaluations made by cosmonaut-researcher Valeriy Polyakov, all five of the cosmonauts are healthy and feeling well.

Cosmonaut Mohmand Performs Adaptation Experiment

18660055i Moscow PRAVDA in Russian 2 Sep 88 p 8

[Article by A. Tarasov, special correspondent at the Flight Control Center]

[Excerpt] One fact of interest is that Abdul Ahad Mohmand has to do not only work of his own but also work for his Bulgarian colleague Aleksandr Aleksandrov on board the "Mir" station, since disks for the computer "Zora" were delivered to the station this time. Such disks were lost in transit at the time of the previous visiting expedition. With sensors attached to points next to his eyes and wearing a cap pressing down on his hair, Mohmand watches a screen, following the red dashes of signals and letting instruments pick up and record movements of eyeballs and periocular muscles, biocurrents of the brain, and cardiac activity. Vestibulovisual interaction during the acute period of adaptation is a problem of space medicine that is still difficult to solve.

Of the whole range of tasks in the "Shamshad" program, Mohmand of course prefers those involving study of natural resources of Afghanistan.

The KATE-140 camera carries the main workload in this program. Its black-and-white photographs of sections of the Earth's surface 450 x 450 kilometers in size yield a spatial resolution as high as 50 meters. This camera will be aided by hand-held motion-picture and still cameras and by visual mapping.

Cosmonauts Perform Adaptation, Geophysical, Biological Studies

18660055j Moscow PRAVDA in Russian 3 Sep 88 p 1

[TASS Report]

[Text] Flight Control Center, 2 September. Cosmonauts Vladimir Titov, Musa Manarov, Vladimir Lyakhov, Valeriy Polyakov and Abdul Ahad Mohmand are continuing their joint work in near-Earth orbit.

Today's agenda calls for medical-biological and biotechnology experiments and geophysical studies.

As usual, the newly arrived crew is performing a considerable number of space medical experiments during the first days of its stay on board the complex. The main tasks of these studies are to determine the cosmonauts' working fitness and evaluate their psychophysiological reactions during the initial stage of adaptation to weightlessness.

The working efficiency of people in space also depends in large measure on ample sleep and rest. In an experiment which Valeriy Polyakov conducted, the quality of sleep was evaluated in accordance with electrophysiological indicators which are recorded by means of special apparatus, and with answers on a questionnaire. Afghan cosmonaut Abdul Ahad Mohmand is to perform a similar experiment.

Within the framework of the geophysical research program "Shamshad," the international crew has conducted photographing and spectrometry of areas in the northwest part of Afghanistan's territory.

A series of biological experiments has begun in the units "Magnitogravistat" and "Svetoblok-G." Research of the development in zero gravity of flax seeds exposed to a non-uniform artificial magnetic field is conducted in the first of these units, while the second is intended for studying interaction between plants and soil bacteria. Experiments for evaluating growth dynamics and development of cultures of animal and plant cells in conditions of space flight are continuing in specialized constant-temperature units.

A period of television communication between Kabul and the orbiting complex "Mir" took place today. While it was in progress, Republic of Afghanistan president Najibullah, general secretary of the Central Committee of the People's Democratic Party of Afghanistan, greeted the international crew warmly and wished the cosmonauts a successful performance of their mission program.

Titov, Manarov, Lyakhov, Polyakov and Mohmand are feeling well, and their morale is good.

The flight of the Soviet-Afghan crew is proceeding normally.

Extensive Medical Experimentation Program Aboard 'Mir'

18660055k Moscow IZVESTIYA in Russian 3 Sep 88 p 1

[Article by B. Konovalov, special correspondent at the Flight Control Center]

[Excerpt] One of physician-researcher V. Polyakov's main tasks is to study in detail how the human organism readjusts itself in new conditions.

An extensive program of medical-biological experiments is being conducted under his unremitting supervision and with the active participation of the Soviet-Afghan crew. It could justly be called an Afghan-Bulgarian-Soviet program. The visiting crew is carrying out every

medical experiment called for by the "Shipka" program, including ones which for technical reasons could not be performed during the Soviet-Bulgarian mission.

Every working day of the cosmonauts ends with one of these experiments—"Opros," which is conducted with the aid of the Bulgarian computer complex "Zora." The cosmonauts respond to a series of questions from this 'electronic psychologist' regarding the state of their health, and this information is transmitted to Earth.

The Soviet-Afghan crew is conducting a total of seven medical experiments with the aid of Bulgarian and Soviet equipment. Visual and hearing functions, for example, are being studied for the purpose of understanding how changes in these functions affect the state of health of cosmonauts. Changes in operator skills are being studied with the aid of the Bulgarian electronic instrument "Pleven-87."

Abdul Ahad Mohmand conducted an experiment called "Cosmonaut's Sleep" on the night of 1-2 September.

Professor A. Yegorov, deputy flight director in charge of medical support, told journalists that all members of the visiting crew have withstood their encounter with zero gravity well, on the whole; so-called "motion sickness," which has been characteristic of many, is not being observed in the visitors.

Research Program Continues in Fourth Day of Soviet-Afghan Mission

18660055l Moscow PRAVDA in Russian 4 Sep 88 p 1

[TASS Report]

[Text] Flight Control Center, 3 September. Vladimir Titov, Musa Manarov, Vladimir Lyakhov, Valeriy Polyakov and Abdul Ahad Mohmand are conducting joint research for the fourth day on board the orbiting complex "Mir."

The crew of the visiting expedition has carried out a large volume of medical experiments which were prepared with specific features of space missions taken into account. Features of the state of the human locomotor system in zero gravity have been studied, and the cosmonauts' working fitness and the quality of their operator activity have been evaluated. Physician Polyakov and Afghan cosmonaut Mohmand took turns conducting an experiment called "Labirint" today. The purpose of this experiment is to study interaction between the human vestibular apparatus and visual system in conditions of space flight.

Vladimir Titov and Musa Manarov have performed a series of experiments for further study of physics of the Earth's atmosphere, using apparatus called "Bosra" which Soviet and Syrian specialists developed, and also a Bulgarian photometer called "Terma." Results of this research will make it possible to obtain new information on physical processes which take place in the upper layers of the atmosphere and the ionosphere and to forecast their condition more precisely.

The cosmonauts purified the latest lot of genetic-engineering interferon in the "Ruchey" unit on 1 September, and yesterday they conducted an experiment for electrophoretic separation of erythrocytes. The purpose of this experiment is to perfect a process for isolating cells of animal origin which possess certain biological properties.

In the course of two periods of television communication today, the international crew held an onboard press conference for Soviet and foreign journalists who are covering this space mission.

According to telemetry information and reports from orbit, the flight of the manned complex "Mir" is proceeding normally. All five of the cosmonauts are healthy and feeling well.

Cosmonauts Begin 'Labirint' Motion Sickness Experiment

18660055m Moscow SOVETSKAYA ROSSIYA in Russian 4 Sep 88 pp 1, 6

[Article by A. Nemov, correspondent]

[Excerpt] The Soviet-Bulgarian crew was unable to find a flexible magnetic disk with the program of the scientific experiment "Labirint" recorded on it, and so this experiment was not performed.

This was frustrating for the scientists, since "Labirint" would make it possible to test a hypothesis which explains features of the course of motion sickness in space. Abdul Ahad Mohmand and Valeriy Polyakov began performing this experiment yesterday.

Candidate of Medical Sciences O.D. Anashkin, head of the medical support group for the mission, related:

"A scientific equipment-complex, 'Zora,' which was built in Bulgaria, is used in this experiment. The movement of human eyeballs, biocurrents of the brain, and cardiac activity are studied with the aid of special pickups. Data which is obtained is fed into the memory of a computer and recorded on magnetic disks. After returning to Earth, the cosmonauts will again undergo examinations whose results will be compared with those obtained in orbit. This will make it possible to judge how weightlessness affects errors of vision, sense organs, etc.

"These observations will help to broaden our notions of effects which space factors of flight produce on human beings, which will certainly be an aid to scientists in preparing more prolonged expeditions."

Crew Begins Preparations For Return to Earth

18660055n Moscow IZVESTIYA in Russian 6 Sep 88 p 1

[TASS Report]

[Text] Flight Control Center, 5 September. Vladimir Titov, Musa Manarov, Vladimir Lyakhov, Valeriy Polyakov and Abdul Ahad Mohmand are completing joint work on board the scientific research complex "Mir."

Today the crew is performing final experiments in line with the program for the Soviet-Afghan mission and making preparations for the return of the spaceship "Soyuz TM-5" from orbit. The cosmonauts are moving exposed motion-picture and photographic film in cassettes, spectrograms, tape recordings, and biological specimens in containers into this spaceship's reentry vehicle. Materials from research which Vladimir Titov and Musa Manarov have carried out in the course of their prolonged work in orbit will also be delivered to Earth.

The "Soyuz TM-5" ship's reentry vehicle is scheduled to land on the morning of 6 September.

A biotechnology experiment which began on 10 June has been completed on board the "Mir" complex. This experiment was conducted in line with an agreement between the soviet Union and Afghanistan. The purpose of the experiment is to obtain single crystals of an influenza-virus antigen in conditions of zero gravity, so that studies of the properties and three-dimensional structure of these crystals can subsequently be made.

According to telemetry data and reports from orbit, the flight is proceeding in accordance with the designated program. All of the cosmonauts are healthy and feeling well.

Lyakhov and Mohmand Depart 'Mir' in 'Soyuz TM-5;' Problem Postpones Landing

18660055o Moscow PRAVDA in Russian 7 Sep 88 p 1

[TASS Report]

[Text] Flight Control Center, 6 September. Joint work of the Soviet-Afghan crew on board the scientific research complex "Mir" has been completed. The spaceship "Soyuz TM-5" with a crew consisting of Vladimir Lyakhov and Abdul Ahad Mohmand, a citizen of the Republic of Afghanistan, was separated from the orbiting complex on 6 September at 0255 hours, Moscow time. A premature automatic shutoff of the ship's descent program occurred as the program was beginning to be executed. It has been decided to postpone the landing of the "Soyuz TM-5" ship to 7 September.

The manned spaceship "Soyuz TM-5" is in standard oriented flight.

Cosmonauts Lyakhov and Mohmand are feeling well.

Problems With IR Sensors, Computer System Forced Postponement of 'Soyuz TM-5 Landing

18660055p Moscow TRUD in Russian 7 Sep 88 p 3

[Article by V. Golovachev, special correspondent at the Flight Control Center]

[Abstract] The article gives an account of the undocking of the spaceship "Soyuz TM-5" from the orbiting station "Mir," and of subsequent events which prevented execution of maneuvers for landing the spaceship's reentry vehicle on the day originally scheduled.

It is recalled that the reentry vehicle and equipment compartment of "Soyuz TM-5" separated from the spaceship's living compartment on schedule. The flight plan called for the ship's braking engine to be fired automatically at 0524.8 hours Moscow time, and for the engine to operate for 213.5 seconds, producing a braking pulse of 115.2 meters per second and sending the ship into a descending path which would bring it to Earth at a point 44 kilometers northeast of Arkalyk. It is noted that the engine would not fire automatically unless the craft were precisely oriented in space. Proper orientation could be accomplished either manually by the station's crew or automatically, using an instrument called an infrared vertical reference. "Soyuz TM" spacecraft are equipped with two such instruments, which determine the direction to the center of the Earth by means of the planet's infrared radiation. This makes it possible to orient the spaceship over either the dark or the sunlit side of the Earth. One problem is that the infrared vertical may not operate stably while the ship is crossing the terminator (the dividing line between the dark and the sunlit sides).

The spaceship's braking engine failed to fire at the appointed time, the author relates. This presumably resulted from unstable functioning of the infrared vertical reference, explained A.P. Aleksandrov, pilot-cosmonaut of the USSR. An onboard computer is supposed to switch the braking system to the second vertical if this happens, but the back-up instrument also did not give a precise orientation at first. The firing of the braking engine was thus delayed for seven minutes. Vladimir Lyakhov, the crew's commander, knew that after such a delay, firing of the engine would cause the reentry vehicle to land hundreds of kilometers to the east of the recovery area. The vehicle might land in the mountains, a city, China or the Pacific Ocean, for example. At the time this problem developed, the control center could not be contacted because the spacecraft was over the Western Hemisphere, outside the center's zone of radio visibility. Lyakhov therefore made what the author calls the only correct decision: when the braking engine finally fired automatically, he cut it off six seconds later from his control panel, without waiting for instructions from the Control Center.

When communications with the center resumed 10 minutes later, specialists of the center approved the crew's actions, it is recalled. It was decided to make another landing attempt in the automatic mode, not on the spacecraft's next orbit but on the one after that, since the craft's automatic equipment was now functioning normally. A specialist at the control center mentioned that no "Soyuz TM" spacecraft had yet been landed with manual orientation. For the purpose of heightening reliability, the infrared vertical was set and the spacecraft oriented in advance, but on the next two firing attempts , the ship's engine operated for only 6 and 50-60 seconds, respectively. The craft's instruments indicated that a disruption of the stabilization procedure had occurred, Lyakhov reported. He thought that this time the trouble lay in the onboard computer, possibly because it had not received an important parameter of the descent program from the ground.

The author relates that the crew's landing was rescheduled for the following day, to ensure descent of the reentry vehicle to the usual recovery area or one of two alternate areas during the daylight hours. This landing would also be made in the automatic mode. The spacecraft's orbit was judged still high enough (apogee-more than 300 kilometers) and its fuel supply adequate for a normal landing; the craft's life-support system was capable of maintaining normal conditions on board for another 24 hours, and the cosmonauts' oxygen supply was sufficient. However, they had only an emergency supply of food, according to Lyakhov.

Cosmonauts Lyakhov and Mohmand Return to Earth Safely on 7 September

18660055q Moscow PRAVDA in Russian 8 Sep 88 p 1

[TASS Report]

[Text] The international crew consisting of Vladimir Lyakhov and Abdul Ahad Mohmand, a citizen of the Republic of Afghanistan, returned to Earth on 7 September 1988, at 0450 hours Moscow time. Both cosmonauts are feeling well after the landing.

As has been reported, the landing of the spaceship "Soyuz TM-5" which was scheduled for 6 September did not take place because of a premature automatic shutoff of the ship's descent program. The Flight Control Center thoroughly analyzed the situation that had arisen and made the necessary decisions for the purpose of ensuring the ship's landing in the target area.

On commands from onboard automation equipment, the spaceship's braking engine was fired on 7 September at 0401 hours Moscow time. After the engine had finished operating, the reentry vehicle of the "Soyuz TM-5" ship separated from its equipment compartment, made a controlled descent into the atmosphere and landed 160 kilometers southeast of the city of Dzhezkazgan.

The mission program of the international Soviet-Afghan crew has been completed. Vladimir Titov, Musa Manarov and Valeriy Polyakov are continuing their work in orbit.

Joint studies and experiments which had been planned were carried out in their entirety by the Soviet and Afghan cosmonauts in the course of their six-day mission on board the manned complex "Mir."

Vladimir Titov, Musa Manarov, Vladimir Lyakhov, Valeriy Polyakov and Abdul Ahad Mohmand operated efficiently and harmoniously at every stage of their joint work.

The Soviet-Afghan space mission which has been successfully completed in further evidence of friendly relations between the peoples of the Soviet Union and Afghanistan.

(A photograph is given showing cosmonauts Lyakhov and Mohmand in space suits and seated in chairs after the landing.)

Computer Error Blamed for 'Soyuz TM-5' Landing Problem

18660055r Moscow PRAVDA in Russian 8 Sep 88 p 1

[Article by A. Tarasov, special correspondent at the Flight Control Center]

[Extract] We are accustomed to shifting the blame for many troubles of spacecraft automatically to the underhandedness of space. But it does not pay to ignore the fact that equipment of our own making has played tricks on us there, as it does on Earth.

At a decisive moment, the onboard command-computer complex [of "Soyuz TM-5"] looked where it was not expected to—into a reserve register, i.e., a memory unit, in which a program that had already served its purpose was stored. It was an engine operation program which was intended for a previous operation of this spaceship: the stage of orbit correction which preceded the docking of the Soviet-Bulgarian crew. The complex suddenly began to operate according to this program instead of the Soviet-Afghan landing program which had been prescribed for it.

Viktor Dmitriyevich Blagov, deputy flight director, told journalists: "In this case, the computer was placed in such a complicated situation that it slyly found a course which we had not stipulated for it. The first time the spaceship's engine was fired, the computer made the correct choice in the proper storage register, but trouble occurred for another reason; automatic equipment cut off the engine because the ship was not reliably oriented. The onboard computer encountered a situation which was like nothing else—a subtle set of events which was not in its program. Something illogical had happened, causing it to 'snap up' another command."

Can people rely completely on electronics and automation equipment, or should they be the most dependable reserve of this equipment? Vladimir Lyakhov solved this problem, too; in a most critical and even stressful situation for him and Ahad, he tried to put a program into operation on his own, outside the zone of contact with the Control Center. But he had to turn to the center for advice after all, since the computer was now 'confused' and had to be controlled precisely. In three brief periods of operation, the engine did not produce the pulse it was supposed to.

And although all of these matters were soon clarified, adjustments were made, the spacecraft's sources of power were quite sufficient and there were still 24 hours to spare, people had to keep putting needless thoughts out of their minds that night.

One can well understand how tense ground personnel were [on the next day] as they followed the Soviet-Afghan crew out of the zone of communication before the braking pulse was applied.

Shortly afterward, an ocean relay station on board the ship "Nevel" transmitted the message that the spacecraft's engine had produced the pulse it was supposed to, only two seconds shorter than specified, and shut off. Lyakhov himself soon announced this in tones which were unusually cheerful and ringing.

"Congratulations!," came the reply from the Control Center, as people there caught their breath; this meant that the cosmonauts would land.

Search and Recovery Operations in 'Soyuz TM-5' Landing Zone

18660055s Moscow KOMSOMOLSKAYA PRAVDA in Russian 8 Sep 88 p 1

[Article by Sergey Leskov, special correspondent at the landing place of the Soviet-Afghan space crew]

[Abstract] The article reports on activities of ground search-and-rescue personnel during the return of the Soviet-Afghan space crew from the orbiting station "Mir."

General-Major K. Subbotin, one of the heads of the search and rescue service, mentioned that personnel were deployed over a vast territory stretching from Arkalyk to Semipalatinsk and Lake Balkhash. A three-level system had been organized for continuous tracking of the "Soyuz TM-5" spaceship's reentry vehicle during its descent to Earth: the top level consisted of airplanes, the middle level of helicopters, and the bottom level of search-and-evacuation vehicles on the ground.

Remarks which the crew of "Soyuz TM-5" made immediately after their landing are recorded. Vladimir Lyakhov commented on the crew's response to problems with the spacecraft's braking engine, relating: "I was in complete control of the situation and could have landed the spacecraft yesterday, but the possibility of landing in a thickly populated area could not be ruled out. It was decided not to take such a risk. Today everything proceeded according to the regular schedule.

Performance of Cosmonauts Lyakhov and Mohmand Praised

18660055t Moscow PRAVDA in Russian 15 Sep 88 p 6

[Article by V. Gubarev]

[Excerpt] Vladimir Lyakhov and Abdul Ahad Mohmand have returned to Star City.

The Soviet-Afghan space expedition is now history.

In Australia, Europe, America and Africa, the events [of Lyakhov's and Mohmand's flight] have been related in detail but, unfortunately, not always objectively. Some journalists have attempted to cast aspersions on the crew's actions, particularly those of commander Lyakhov.

All details of these events, the first of their kind to occur in orbit, will be carefully studied by a competent commission, of course. The cosmonauts did not rehearse such a situation even during their training exercises. But it is not clear that their ship's onboard computer needed more careful supervision and control. That a portion of a program was 'left' in this computer and that its monitoring from Earth was faulty cannot be doubted.

"We had only an emergency supply of water and food, but we decided not to touch it, since all of it might be needed after landing," related V. Lyakhov. "The most unpleasant thing was that we were almost completely immobilized in a double-up position. We unfastened ourselves from our seats for only a few seconds in order to stretch our muscles and relax a little."

V. Lyakhov and A. Mohmand passed their rigorous test in space with honors.

FTD/SNAP

Cosmonaut EVA to Replace Unit of 'Kvant' Telescope

Cosmonauts Begin Preparations for EVA to Repair 'Kvant' Module Telescope

18660056a Moscow PRAVDA in Russian 7 Oct 88 p 1 [TASS Report]

[Text] Flight Control Center, 6 October. The space mission of Vladimir Titov, Musa Manarov and Valeriy Polyakov on board the orbiting complex "Mir" is continuing.

The crew's work plan today calls for geophysical and medical research and routine maintenance of individual onboard systems of the complex.

Several periods of observations of the supernova in the Large Magellanic Cloud and of an x-ray pulsar in the constellation Hercules are planned in line with the international program of astrophysical experiments "Rentgen."

Preparations for an egress into open space have begun. The cosmonauts are to continue work on replacing a detector unit of one of the x-ray telescopes installed on the outer surface of the "Kvant" module. The cargo spaceship "Progress-38" delivered additional tools and equipment to the orbiting complex for the purpose of completing the planned operations.

According to results of medical monitoring, the condition of Vladimir Titov's, Musa Manarov's and Valeriy Polyakov's health is good.

The flight is proceeding normally.

Final Preparations for Cosmonaut EVA

18660056b Moscow PRAVDA in Russian 19 Oct 88 p 1

[TASS Report]

[Text] Flight Control Center, 18 October. Vladimir Titov, Musa Manarov and Valeriy Polyakov are continuing to carry out planned work on board the scientific research complex "Mir."

A series of observations of an x-ray pulsar in the Small Magellanic Cloud has been conducted within the framework of the international program of astrophysical experiments "Rentgen."

The crew is completing preparations for an egress into open space. Work which Vladimir Titov and Musa Manarov will perform on the outer surface of the station will begin on the morning of 20 October. Physician-researcher Valeriy Polyakov will monitor the functioning of onboard systems of the base block and the condition of the commander's and flight engineer's health from inside the complex.

The flight of the manned complex is proceeding in accordance with the designated schedule. The condition of the cosmonauts' health is good, and they are feeling well.

Cosmonauts Successfully Replace Detector Unit in 'Kvant' Telescope

18660056c Moscow PRAVDA in Russian 21 Oct 88 p 1

[TASS Report]

[Excerpt] Flight Control Center, 20 October. Cosmonauts Vladimir Titov and Musa Manarov have made an egress into open space. The main purpose of this egress was to replace a detector unit in one of the x-ray telescopes of the astrophysical module "Kvant." This unit was developed jointly by specialists of the Netherlands and Great Britain.

A stage of training preceded the execution of these complex installation operations. During this stage, the cosmonauts studied plans and specifications for installing the new instrument, and they and specialists of the Flight Control Center jointly determined a procedure for operations on the outer surface of the orbiting complex. In support of work on replacing the detector unit, new tools were delivered to the manned complex by the cargo spaceship "Progress-38."

Today Vladimir Titov and Musa Manarov opened an outer hatch and went out of the station at 0959 hours, Moscow time.

The work on replacing the detector unit was carried out in several stages. The cosmonauts removed thermal-insulating covering and freed the instrument from its fastening devices. They then installed a new detector unit in place of the dismounted one, connected electric cables to it and restored thermal-insulating covering of the module's outer casing.

The new detector unit, whose characteristics are improved, was installed in line with a joint decision of specialists of the Soviet Union, the Netherlands and Great Britain. The unit will make it possible to lengthen the time that the telescope is in operation.

New Spacesuits Tested by Cosmonauts During EVA

18660056d Moscow KRASNAYA ZVEZDA in Russian 21 Oct 88 p 3

[Article by Lieutenant Colonel Baberdin]

[Abstract] The article gives an account of operations which cosmonauts Vladimir Titov and Musa Manarov performed during their most recent egress from the orbiting complex "Mir." The main purpose of this egress was to replace a detector unit of one of the complex's radio telescopes.

It is recalled that a similar operation which Titov and Manarov attempted last summer failed because the cosmonauts were unable to open the lock of a band which fastens the detector unit to the telescope. A more extensive set of equipment was developed for the next

attempt and transported to "Mir" by cargo spaceships. In particular, the cosmonauts received materials for training exercises, including a mock-up of the section of the telescope which includes the detector unit. All possible versions of opening the band were devised. They ranged from a simple version employing a small two-ended screwdriver and a screw jack to a laborious operation employing an electrical cutter, drills and a breaking mechanism. Special tools for these operations were developed and delivered to the orbiting complex, as well as a set of bands for fastening the new detector to the telescope. These bands were produced in the Netherlands and tested in extreme conditions.

M. Balashov, an engineer in charge of testing space garments, commented on features of new space suits which the cosmonauts tested during the latest egress. The principal merit of these suits, according to Balashov, is that they can be completely self-contained. Whereas space suits of earlier models are equipped with lines through which power is supplied and communications maintained with the wearer, the new suits can operate without such lines, he explained. A high-strength composite fabric that is softer and more elastic is employed in the new suits' sleeves and legs, which can be removed for mending and replaced with others. Heavier-duty electric motors are installed in the suits' ventilating systems. Each suit is equipped with a medical unit for regulating the wearer's body temperature, making cardiograms and analyzing respiration. New gloves which were developed for the suits permit greater mobility of hand joints.

New Tools Developed for Telescope Repair Operation

18660056e Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 21 Oct 88 p 1

[Article by G. Lomanov, Special correspondent at the Flight Control Center]

[Abstract] The article records conversations with specialists and Flight Control Center officials regarding work which cosmonauts Titov and Manarov did during their most recent egress from the orbiting complex "Mir."

A locked band must be removed from the detector unit of an x-ray telescope of the complex before the detector can be replaced, explained Oleg Semenovich Tsygankov, an engineer who has developed many implements for space installation work. One problem is that this unit is not designed for replacement in open space, and devices which fasten it to the telescope are difficult to reach. The failure of last summer's attempt to replace the detector meant that a whole set of special equipment would have to be prepared for unlocking the band, or loosening or breaking it if the lock could not be opened. Suitable tools would have to be designed and their fitness tested in simulated zero gravity. Seven different tools were eventually built by engineers and delivered to the crew of "Mir," Tsygankov related. Among these implements were a screw-type puller similar to those which mechanics on Earth use for fitting bearings to shafts, a miniature emery cutter with a self-contained electric motor, and a drill for boring through pins which fasten segments of the band together.

It is noted that the cosmonauts' work in open space was scheduled to last for 5 hours and 10 minutes. Since the modernized spacesuits they wore are designed to operate safely for 6 hours at a time, Titov and Manarov had only a minimal time reserve if unforeseen problems arose. In addition to replacing the detector and testing the space suits, the cosmonauts had to install a short-wave radio antenna and a securing device called "Yakor" (anchor) on the outside of the orbiting complex, and (if time permitted) clean two windows of the "Kvant" module from which mooring of spaceships can be watched. The antenna is intended for amateur radio communication with "Mir," and the securing device is intended for facilitating work in open space which a Soviet-French crew is scheduled to perform, explained deputy flight director V. Blagov. A brush made of soft copper was provided for cleaning the windows. Although the cosmonauts did not have time to do this properly, they opened the lock on the detector in a matter of minutes and carried out the rest of their program successfully, Blagov reported.

Cosmonaut Polyakov's Position in 'Soyuz TM-6' Descent Craft Explained as Precaution

18660056f Moscow TRUD in Russian 21 Oct 88 p 2

[Article by V. Golovachev, correspondent (Kaliningrad, Moscow Oblast)]

[Abstract] The article gives an account of operations which the crew of the orbiting complex "Mir" carried out recently for the purpose of replacing a detector unit of one of the station's telescopes.

The author notes that these operations in open space differed from earlier ones performed by three-man crews in that the cosmonaut-researcher did not remain inside the "Mir" station itself. This time, physician-researcher Valeriy Polyakov was stationed in the reentry vehicle of the transport spaceship "Soyuz TM-6" while the other two members of the crew—Vladimir Titov and Musa Manarov—were working on the outer surface of the complex. This was done for the purpose of maximizing the cosmonauts' safety, it is explained. Very bulky objects had to be carried outside the station. They included not only the new detector unit, which is more than half a meter in diameter and has a mass of 50 kilograms, but also a foot anchor, and a girder for installing this anchor on the outside of the station. Titov and Manarov had to exit through the adapter module which connects the "Mir" station with "Soyuz TM-6." The airtight hatches of both the module and the spaceship had to be opened in the process.

The version of the egress which specialists prepared in advance was intended for protecting the cosmonauts in the unlikely event that the adapter module and transport spaceship could not be made airtight after Titov and Manarov reentered them. If this happened, the two cosmonauts would have to return to Earth at once in "Soyuz TM-6." If Polyakov were inside the working compartment of "Mir" at the time, he would be left alone on board the station. It was therefore decided that all three members of the crew should leave the station at the same time, since the reentry vehicle of "Soyuz TM-6" can accommodate three cosmonauts wearing space suits of the type intended for egresses into open space.

Installation of New Unit Enhances Performance of Telescope

18660056g Moscow IZVESTIYA in Russian 26 Oct 88 p 1

[TASS Report]

[Text] Flight Control Center 25 October. The flight of the scientific research complex "Mir" is continuing.

As has been reported, Vladimir Titov and Musa Manarov replaced a detector unit in an x-ray telescope of the module "Kvant" during an egress into open space on 20 October. This unit was replaced with a new one with improved characteristics, which specialists of the Netherlands and Great Britain developed. Four sessions of work employing all of the telescopes of the international observatory "Rentgen" subsequently took place. An x-ray image of the central region of our galaxy was obtained in the course of these experiments. Spectrograms of the three most intense x-ray sources in this area of the celestial sphere have been analyzed in detail at the USSR Academy of Sciences' Institute of Space Research. This analysis demonstrated that the capabilities of the "Rentgen" observatory's research equipment have expanded substantially since the detector unit was replaced.

Today's program of work in orbit includes astrophysical and geophysical experiments and medical research.

Study of flows of electrons and positrons and their travel in near-Earth space will be continued, using the magnetic spectrometer "Mariya."

Within the framework of an extensive program for study of the environment, the cosmonauts are photographing various regions of our country's territory, including the Ukraine, Krasnodar and Stavropol krays and coastal waters of the Caspian Sea.

Valeriy Polyakov will conduct a comprehensive examination of the cardiovascular system in accordance with the medical monitoring schedule.

The work in space is proceeding in line with the designated program. The cosmonauts are feeling well.

FTD/SNAP

'Mir' Antenna, Transceiver For Amateur Radio Communication

18660066 Moscow SOVETSKAYA ROSSIYA in Russian 1 Nov 88 No. 252 (9803) p 4

[Article by N. Dombkovskiy]

[Excerpt] You may recall that during their last egress into open space, Musa Manarov and Vladimir Titov installed a special antenna for amateur radio communication on the outer surface of the orbiting complex "Mir." A small transceiver which Valeriy Agabekov, permanent correspondent of our radio room, had sent from Yessentuki was delivered to the station shortly before the egress was made. An experiment for conducting amateur communications from space has been organized by the USSR Radio Sport Federation and the editors of the magazine RADIO.

Musa and Vladimir will begin work over the airways in approximately two weeks, as soon as a time can be chosen which is not taken up by experiments. The coordinators on Earth will be Valeriy Agabekov and a radio station of the USSR Center for Control of Amateur Radio Satellites. This station is located in Moscow.

The onboard radio station will operate at a frequency of 144.500 megahertz in the narrow-band FM mode.

TASS Reviews Cosmonauts' Year in Space

LD1101093289 Moscow TASS in English 0840 GMT 11 Jan 89

[Text] Moscow January 11 TASS—By TASS correspondent Vladimir Isachenkov:

Soviet space veterans, Vladimir Titov and Musa Manarov, who on December 21 last year completed a 365-day mission, have nearly fully restored their weight, the volume of muscular tissue and vestibular functions, this correspondent was told by Anatoliy Grigoryev, director of the USSR Health Ministry Institute of Medical-Biological Problems.

He said that during the flight Vladimir Titov lost nearly three kilograms in weight, while Musa Manarov, on the contrary, gained nearly two kilograms. Jean-Loup Chretien, who spent 25 days in space before returning to earth with them, lost 900 grams.

Titov and Manarov developed partial muscular atrophy of the shins, which is a usual consequence of a long stay in zero-gravity. According to information obtained immediately after the landing, the volume of the cosmonauts' shins decreased by nearly 20 per cent—a little more than Yuriy Romanenko lost during his 326-day

flight two years ago. However, this is not the highest figure because after several flights of less duration doctors observed a 25 per cent lessening of the volume of shin muscles. This was largely due to the loss of intramuscular fluid and not of muscular tissue. This also explains the rapid rehabilitation.

Grigoryev said data on the state of bone tissues of the cosmonauts was still being processed. But preliminary results show that the lessening of calcium was not as significant as after several previous missions. Immediately after their touch-down, Vladimir Titov and Musa Manarov suffered from the minor changes of vestibular functions, which passed quickly, and from traditional changes in the water-and-salt metabolism which showed in 5-6 per cent reduction of the content of potassium in the blood.

Soviet specialists have worked out a whole programme of rehabilitation measures which includes jogging, swimming and exercising with a variety of equipment. Grigoryev said that, from the fifth day after landing, Vladimir Titov and Musa Manarov walked three to four kilometers and swam 400-500 meters in the swimming pool. At this time they started intensive training of the muscles of the back, shin and thighs, for around one hour every day.

In mid-January Vladimir Titov and Musa Manarov will go to Kislovodsk to rest, where alongside walking, swimming and physical exercises they will play games and take mountain walks. They should completely restore their pre-flight physical form on the 60th-70th day after the landing, by the end of February.

"After this we will again study in detail the state of bone tissue and the metabolism," Anatoliy Grigoryev said. "Medical control will also be exercised after this for a long time. We must be completely convinced that no unfavorable consequences were left by such a long flight."

News Conference on Year-Long Flight of Titov and Manarov

LD1801175288 Moscow TASS in English 1301 GMT 18 Jan 89

[Text] During their year-long flight aboard the Mir orbital complex, Vladimir Titov and Musa Manarov held approximately 2,500 sessions of scientific experiments using 150 various methods, a news conference was told here on Wednesday. A wide-ranging programme of astrophysical, geophysical and medical research, technological and biotechnological experiments has been fully implemented.

"Our record-setting flight has underlined the reliability and high efficiency of Soviet space technology—the 'Mir' complex, transport spacecraft 'Soyuz TM' and cargo vehicles 'Progress'," said Vladimir Titov. "During our work in orbit we made three spacewalks. During the first one we installed a new section of solar batteries and during the others replaced a detector unit in one of the roentgen telescopes of the astrophysical modules 'Kvant'."

Speaking about the flight's scientific programme, Musa Manarov dwelled upon the observations, held from space in different seasons, of the more productive agricultural regions of the USSR. They will have great significance for raising the yield of agricultural crops. The pollution of the atmosphere and water reservoirs was also checked. Under the programme of biotechnological research samples of genetically engineered interferon with the high degree of refinement were obtained and experiments on separating blood erythrocytes into fractions held.

During the flight Vladimir Titov and Musa Manarov played host to three international crews with the participation of Bulgarian, Afghan and French cosmonauts. The Soviet-French flight became the longest international expedition. Over 23 days of work on board the Soviet orbital complex, five Soviet and a French cosmonaut carried out nine series of medico-biological and technological experiments.

French research cosmonaut Jean-Loup Chretien noted that the spacewalk was the most difficult part of the scientific programme of the French-Soviet flight. During the flight he and Aleksander Volkov were to carry out the installation and deployment of large-size framework structures of carbon tubes. Because of the technical problems, the spacewalk took six hours instead of the planned four hours and 20 minutes.

It was noted at the news conference that the record flight of Vladimir Titov and Musa Manarov could be impossible without the permanent medical control and strict fulfillment of the programme of preventing the impact of zero-gravity. After the flight the cosmonauts rapidly adapted themselves to earth conditions. "Analyzing the state of Titov and Manarov we came to the conclusion that there have been no qualitative changes in their organisms as compared with the cosmonauts who spent less time in space flights," said Anatoliy Grigoryev, director of the Institute of Medico-Biological Problems of the USSR Health Ministry. "As of today there is no medical evidence to advise against longer flights."

Phobos Mission

Preparations for Launch of Phobos Mission

18660017a Moscow IZVESTIYA in Russian 8 Jul 88 p 3

[Article by A. Ivakhnov, correspondent]

[Excerpt] July is the month for launching the new-generation Soviet automatic research stations "Phobos-1" and "Phobos-2" to the vicinity of the planet Mars.

The "Phobos" stations are new spacecraft in the class of so-called highly intelligent space robots.

Radio telescopes located in suburban Moscow, Yevpatoriya, Ussuriysk and West Europe and on other continents will receive messages which main units of the "Phobos" spacecraft will transmit from the automatic stations to Earth.

And this is not all of the program. Long-term stations and a so-called "small mobile probe" will land on Phobos simultaneously. This probe will hop across the surface of Phobos and study soil at the points where it stops.

Soon after that, the spacecraft themselves will shift into orbits of artificial Mars satellites and continue research of Phobos, Mars itself, the sun and interplanetary space. The "Phobos" stations' mission will last a total of 460 days.

The "Phobos" has a powerful "Proton" launch rocket. Its dimensions are very impressive; its height without a payload is more than 44 meters, and its broadest section is about 7.5 meters in diameter.

A large group of scientists from various countries is observing the launch at Baykonur. Many of these scientists took part in development of equipment for the "Vega" stations.

Soviet scientists headed by Academician R. Sagdeyev, director of the USSR Academy of Sciences' Institute of Space Research, became the initiators of the "Phobos" stations' development.

(A photograph of the "Phobos" station is given.)

Scientific Equipment Carried by Phobos Spacecraft

18660017b Moscow KRASNAYA ZVEZDA in Russian 8 Jul 88 p 4

[Article by V. Baberdin, colonel, correspondent at the Flight Control Center]

[Abstract] The article reports on activities at the Flight Control Center during the launch of the first of two unmanned interplanetary stations which are to be used in studies of the planet Mars and its satellite Phobos. Representatives of the European Space Agency, Bulgaria, France and other countries which took part with the USSR in development of equipment for the "Phobos" project are quoted in regard to the project's history, and design features and equipment of the interplanetary stations.

Adapting space laboratories to the conditions of different planets, comets and asteroids is one of the biggest problems which designers of such spacecraft have solved, according to R. Kremnev, director of the Research and Testing Center imeni Babakin and a laureate of the Lenin and USSR State prizes. If all of the equipment needed for approaching Phobos were installed, for example, on a "Venera" interplanetary station in addition to the station's most essential equipment, the weight of the spacecraft would exceed the maximum permissible weight by more than a ton. The design arrangement of the "Phobos" spacecraft is said to permit installation of additional research and auxiliary equipment or installation of completely different sets of instruments in their upper hemispheres.

The equipment carried by the "Phobos" stations includes a laser which Soviet specialists designed for studying the composition of Phobos' soil. This unit will be switched on 50 meters above the Martian satellite's surface and can be precisely adjusted for an altitude of 30 centimeters, it is claimed. The laser generates a beam 3-4 millimeters in diameter, and the power density in the spot of light where the beam strikes the surface of Phobos will be more than 10 milliwatts. This is considered sufficient to vaporize instantly dust coating the surface of Phobos. Bulgarian specialists are credited with developing a highly sensitive device called a "reflektron" for detecting particles of this vapor. It is planned to record approximately a million particles during a single series of measurements. The Bulgarian scientists foresee use of the "reflektron" also in terrestrial conditions. The space version of this instrument is made of a special composite material which is said to reduce its weight by 16 percent.

A. Laplace of France's National Center for Space Research related that French scientists developed eight instruments for the "Phobos" project, including an ion source for probing the surface of Phobos from an altitude of 50-100 meters, and video cameras for photographing the satellite's surface. French scientists plan to take part also in solving problems of space navigation. A representative of the European Space Agency mentioned that specialists of this agency developed instruments which the interplanetary stations carry for recording electromagnetic waves and transits of particles with very high energies. ESA representatives will take part in calculating the stations' flight path.

Cost Estimates Given for Building, Launching Phobos Spacecraft

18660017c Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 9 Jul 88 p 3

[Excerpt] The first Soviet unmanned station "Phobos" has been launched to the planet Mars.

"A laser beam and a powerful beam of ions from the station will strike the surface of Phobos," related A. Galeyev, corresponding member of the USSR Academy of Sciences and deputy scientific director of the project. "Vaporized matter will reach the station and be analyzed by its instruments."

A most interesting program is planned. Each station is equipped with 20 instruments; the total weight of this scientific apparatus is more than half a ton. How much does such scientific curiosity cost nowadays? This question was heard at a press conference a few days before the launch. V. Balebanov, deputy director of the USSR Academy of Sciences' Institute of Space Research, reported that development of the Soviet instruments had cost roughly 40 million rubles and that other countries which had prepared research equipment for the "Phobos" stations spent approximately the same amount in dollars.

"To this must be added the cost of launching a station with a 'Proton' rocket—another 40 million rubles," added R. Kremnev, director of the Research and Testing Center imeni Babakin. "According to estimates made by our center, expenditures for building a station itself are four to five times higher than expenditures for launching it. In short, the flight of each 'Phobos' costs approximately 300 million rubles."

Phobos-1 Spacecraft Launched on 7 July

18660017d Moscow PRAVDA in Russian 9 Jul 88 p 1

[TASS Report]

[Text] In line with the program of research of outer space and of planets of the solar system, an unmanned interplanetary station, "Phobos-1," was launched from the Soviet Union on 7 July 1988. A four-stage "Proton" launch rocket placed this station, which has a mass of 6,220 kilograms, into a trajectory for a flight to the planet Mars.

The international project "Phobos" calls for two interplanetary stations to be launched to Mars for the purpose of conducting research of this planet, its satellite Phobos, the sun and interplanetary space.

These stations, which are unmanned spacecraft of a new generation, were developed at the Research and Testing Center imeni Babakin of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos), with the participation of many of the country's design and industrial enterprises. Together with Soviet scientists, specialists of Austria, Bulgaria, the Hungarian People's Republic, the German Democratic Republic, Ireland, Poland, Finland, France, the Federal Republic of Germany, Czechoslovakia, Switzerland, Sweden and the European Space Agency took part in drafting the research program of the "Phobos" project and developing a set of scientific apparatus and equipment for it.

The unmanned station "Phobos-1" will reach the vicinity of the planet late in January of 1989 and conduct remote studies of its surface and atmosphere from the orbit of a satellite of Mars. The station's approach to Phobos will be accomplished by means of independent onboard navigational measurements of parameters of the motion of the station and Phobos in relation to each other.

For the purpose of studying Phobos comprehensively, plans call for the station to fly by Phobos at a distance of several tens of meters from its surface. During this period, it is proposed to study the element and isotopic condition of soil on the surface of this celestial body by means of laser and ion probing, for the first time in the history of planetary experiments.

An independent lander probe will separate from the station during its approach to Phobos. This probe will conduct scientific experiments and take television pictures of the Martian satellite's surface at the place of landing. The lander probe's program of scientific work calls for prolonged observations of the probe to be made with the aid of a system of ground radio telescopes of the USSR and the United States and an international radioastronomy network.

Control of the unmanned interplanetary stations is being accomplished by the Flight Control Center of USSR Glavkosmos in suburban Moscow and the Space Telecommunications Center in Yevpatoriya.

Scientific information received from the station will be processed at the Flight Control Center, the Space Telecommunications Center, the USSR Academy of Sciences' Institute of Space Research, and other Soviet and foreign research centers that are taking part in the international project "Phobos."

According to telemetry information, the "Phobos" station's onboard systems and scientific apparatus are functioning normally.

The launch of the automatic station "Phobos-2" is planned for 12 July 1988.

Procedure for Placing Phobos Spacecraft on Mars Trajectory

18660017e Moscow KRASNAYA ZVEZDA in Russian 13 Jul 88 p 3

[Article by Lt Col V. Baberdin]

[Excerpt] The station "Phobos-1" had begun its trip. Transmission of telemetry information from the spacecraft to the Flight Control Center via telemetry channels was proceeding in good order. It was now the turn of "Phobos-2."

The plan for placing it into its flight trajectory was the same. The station would first go into the orbit of an artificial Earth satellite with the parameters: maximum altitude—180-190 kilometers; minimum altitude—just over 140 kilometers; period of revolution—about 1.5 hours. Three stages of a "Proton" launch rocket are used to place it into this orbit. The fourth or boost stage, which is intended for the intermediate launch of the spacecraft from its near-Earth orbit, would take place about 75 minutes after the spacecraft left its launching pad at Baykonur. The fourth stage of the "Proton" would operate for 539 seconds; it would then separate, and the independent engine of the "Phobos-2" interplanetary station itself would be fired. After that, "Phobos-2" would move by inertia, subject to the laws of celestial mechanics. An initial maneuver was scheduled to take place 7 to 10 days after the launch, and two other course corrections would be executed during the approach to Mars.

Phobos Mission Control Located in New Building at Flight Control Center

18660017f Moscow MOSKOVSKAYA PRAVDA in Russian 13 Jul 88 p 1

[Article by V. Ovcharov, special correspondent at the Flight Control Center]

[Excerpt] The "Phobos-1" interplanetary station's back-up, "Phobos-2," has gone into a near-Earth orbit, following the space path that the first station took on 7 July. Following acceleration, "Phobos-2" will set out over an Earth-to-Mars route and shoot into space at escape velocity, a million kilometers behind the first station.

All of one's surroundings still appear unusual inside a new Flight Control Center (TsUP) building that has just been completed.

One new room is intended for controlling promising spacecraft, related V. Udaloy, deputy head of TsUP. This room is outfitted with the most modern computer technology, equipment for displaying diverse kinds of information, and modern control consoles for operators. It is equipped in particular for color signaling; if any parameters of a spacecraft deviate from the norm, this will immediately catch the attention of specialists on duty.

V. Kovtunenko, corresponding member of the USSR Academy of Sciences and scientific director of the Research and Testing Center imeni Babakin, noted that a wealth of experience acquired in recent decades during development of Soviet interplanetary stations is concentrated in the "Phobos" spacecraft. In particular, a new engine was developed for them whose performance is superior to that of similar spacecraft which were used previously. A "Phobos" station's control complex, which includes a modern onboard computer, combines functions of three systems: control, orientation, and electronic automation. It cost the developers of this complex quite a bit of effort to develop software and algorithms for it and debug them with the aid of models and testing units. Especially complex problems had to be solved in connection with future astronavigational measurements of Phobos, with braking the stations and correcting their flight paths, and with the stations' approach to Phobos and hovering over it.

The "Phobos" spacecraft will receive help from Earth only during the initial stage of their operations near Phobos. After that, all of their operations will be controlled by their onboard computers, which are to analyze incoming information routinely and issue all necessary commands.

Phobos-2 Spacecraft Launched on 12 July

18660017g Moscow PRAVDA in Russian 14 Jul 88 p 1

[TASS Report]

[Text] An unmanned interplanetary station, "Phobos-2," was launched from the Soviet Union on 12 July 1988, with the aid of a four-stage "Proton" rocket.

As has been reported, the flight program of the two Soviet interplanetary stations, which were developed in line with the "Phobos" project, calls for research of the planet Mars, its satellite, interplanetary space and the sun.

The first station was placed into a trajectory for a flight to Mars on 7 July 1988. The two stations are largely similar in terms of design and the purposes for which they are intended, but the second station, unlike the first, carries two lander probes for research of Phobos. One of these probes, like that of the first station, is intended for conducting research and taking television pictures at the place of landing. A device of the second probe will enable it to make hopping movements for the purpose of obtaining data on characteristics of Phobos' surface at different points on the surface.

The launch of the two interplanetary stations will make it possible to carry out independent comprehensive studies of Phobos and will heighten, on the whole, the probability of carrying out the complex scientific-technical program.

Both stations will reach the vicinity of the planet Mars late in January of next year. The stations' flight paths are close to the calculated ones. Their onboard systems and scientific equipment are functioning normally.

Flight tests of new-generation unmanned spacecraft have begun with the launching of the stations "Phobos-1" and "Phobos-2" from the Soviet Union. These stations were developed at the Research and Testing Center imeni Babakin of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research on the basis of experience amassed by Soviet cosmonautics in the course of flights to the Moon, the planets Venus and Mars, and Halley's Comet. Stations of the "Phobos" type will be used as basic unmanned spacecraft in research of planets of the solar system, including implementation of a Mars program which opens up broad prospects for further advancement of international cooperation in the peaceful exploration of space.

Telescope of Sanglok Observatory To Track Mars and Phobos

18660017h Moscow PRAVDA in Russian 14 Jul 88 p 3

[Text] Astrophysicists of the Tadzhik SSR are taking an active part in a program of terrestrial research of the planet Mars and its satellite Phobos while the flight of spacecraft in line with the "Phobos" program is in progress. It is proposed to obtain more precise data on the positions of Mars and its satellite for the purpose of ensuring that the spacecraft are placed into the calculated orbit around Phobos. For this purpose, Mars and Phobos will be photographed regularly with the 1-meter telescope of the Sanglok high-elevation observatory.

(A photograph of the telescope is given.)

FTD/SNAP

Radio Contact Lost With 'Phobos-1' Spacecraft

18660026 Moscow PRAVDA in Russian 10 Sep 88 p 1

[TASS Report]

[Text] Flight Control Center, 9 September. The flight of the unmanned interplanetary stations "Phobos-1" and "Phobos-2" toward the planet Mars is continuing.

During the two months which have passed since the launch, 75 periods of radio communication with these spacecraft have been conducted, during which parameters of their flight paths have been measured and the functioning of onboard systems and research equipment has been monitored.

On September 2, the regular period of radio communication with the station "Phobos-1" did not take place as planned. The distance of this station from Earth was 17 million kilometers at the time. A control group is analyzing possible reasons for this lack of communication and taking measures to restore it.

The station "Phobos-2" is continuing to move in a path which is close to the calculated one. Its distance from Earth was 19 million kilometers on 9 September. According to telemetry data, the onboard systems and scientific equipment of the "Phobos-2" station are functioning normally.

During the stations' flight over the Earth-to-Mars route, data on physical processes occurring on the Sun and in interplanetary space have been obtained with the aid of instruments installed on the stations. Specialists of the European Space Agency and countries which are participants of the project are taking part jointly with Soviet scientists in processing and analyzing scientific information.

FTD/SNAP

Attempts to Restore Contact With 'Phobos-1' Spacecraft

18660027 Moscow PRAVDA in Russian 4 Nov 88 p 1

[TASS Report]

[Text] Flight Control Center, 3 November. Work on carrying out the international project "Phobos" is continuing.

The sun and interplanetary space were studied in the course of 39 periods of communications which were conducted with the station "Phobos-1" in July-August. More than 140 x-ray images of the sun were obtained from this station with the aid of a telescope-coronagraph called "Terek", which was developed by specialists of the USSR and the Czechoslovak Socialist Republic. These images contain unique information on the structure and dynamics of active regions in the sun's atmosphere.

As has been reported, the regular period of radio communication with the "Phobos-1" station did not take place on September 2, as planned. Attempts to resume communications which the control group continued for a month and a half yielded no results. Work on restoring radio contact with the station has now been discontinued.

Plasma processes in outer space are being studied along the route of the Earth-to-Mars flight with the aid of research equipment installed on the unmanned station "Phobos-2". New data have been obtained on parameters of interplanetary magnetic fields, the solar wind and plasma waves. A large number of solar flare-ups and space x-ray and gamma bursts were recorded from this station during the period from July to October.

Test activations of television equipment are being conducted in the course of the flight. On October 10, a video-spectrometry apparatus called "Fregat" was calibrated during a period of observation of the star Canopus.

Soviet and American radio telescopes have been enlisted in work in line with the "Phobos" project since October 14. These telescopes are measuring parameters of the "Phobos-2" spacecraft's movement. A special transmitter on board the station which emits radio waves 18 centimeters long was switched on at the specified time for this purpose. Radar detection and ranging of the planet Mars from Earth has been conducted during the same period, for the purpose of ascertaining parameters of Mars' movement more precisely.

Continuing its movement along the calculated flight path, the "Phobos-2" station has reached a distance of 60 million kilometers from Earth as of November 3. According to telemetry data, the station's onboard systems and research equipment are functioning normally.

FTD/SNAP

'Phobos' Probe Approaching Mars Orbit

LD2301210689 Moscow TASS in English 1820 GMT 23 Jan 89

[Text] Moscow January 23 TASS—The deep space probe "Phobos", launched towards Mars on July 12 last year, is continuing its flight.

The probe's flight path was adjusted today. To carry out ballistic calculations needed for that purpose, researchers used the results of measurements conducted by Soviet ground control stations across national territory and radiotelescopes situated in Goldstone, United States, Madrid, Spain and Canberra, Australia.

Measurements conducted after the manoeuvring showed that the "Phobos" probe is continuing movement along the path close to the calculated one.

As of today, the space probe is 177 million kilometres from Earth. On January 29, the "Phobos" will be transferred to the orbit around Mars.

186 radio communications sessions have been conducted with the spacecraft, aimed at investigating the sun and interplanetary environment, registering bursts of gamma radiation, measuring parameters of the flight path and monitoring the operation of on-board systems.

The on-board systems and scientific instruments are functioning normally.

To Enter Orbit 29 Jan

LD2501205189 Moscow TASS in English 1747 GMT 25 Jan 89

[Text] Moscow January 25 TASS—The space probe "Phobos" has covered nearly half a billion kilometres in two hundred days and is approaching Mars. On January 29, when it is a mere 800,000 km from the red planet, the unmanned spacecraft will begin an important operation of entering the Mars orbit.

The probe's engines will be started and begin braking for about 200 seconds. The craft will enter an extended elliptic orbit revolving around Mars at the minimum distance above its surface of 800 km and the maximum distance of 80,000 km.

The Phobos will take about three Earth years to complete a circle around Mars. But deviations in flight path adjustments may change the parameters of its orbital travel as a mere eight minutes will be left for all operations after the completion of the braking process. The probe will then enter a "shadow" zone and communications with it will be temporarily interrupted.

'Phobos' Reaches Martian Orbit 29 January

Background to Project Reviewed

LD2901130989 Moscow TASS in English 1303 GMT 29 Jan 89

[Text] Moscow January 29 TASS—By TASS correspondent Rena Kuznetsova:

The Soviet space probe P'obos is to be boosted to a Martian orbit at '5:55 mi utes on Sunday.

The maneuver bringing it to the flight path around the red planet will be executed by firing the craft's engine.

Phobos lifted off on July 12, 1988, to investigate Mars and its moon Phobos as well as the sun and interplanetary space.

A total of 186 communications sessions have been held with the vehicle en route to the red planet.

Apart from the Soviet Union, the research project involes more than ten other countries as well as the European Space Agency.

There are more hypotheses—fantastic, daring and spellbinding—connected with Mars than with any other planet in the solar system. The fascinating propsect of finding life there has long excited mankind's imagination.

Our body of knowledge about the planet has grown considerably following missions by Soviet and U.S. space probes. It is known, for instance, that Mars has a very rarefied atmosphere, consisting of 95 percent carbon dioxide.

Low temperatures and the absence of the photosynthesis and of a magnetic field cut the ground from under the feet of those hoping for some life form on Mars.

The current Martian mission by Phobos will hopefully lift the veil of mystery a little.

One of the primary objectives of the experiment is to obtain a temperature map of Martian surface, study how its temperature patterns change daily and seasonally, measure the thermal inertia of Martian soil, and identify heat- emitting and permafrost areas.

In this way or another, all this is also connected with the search for signs of life. Besides, the findings will give scientists an idea of the mineral makeup of Martian soil as well.

Orbit Parameters Given

LD2901225389 Moscow TASS in English 2238 GMT 29 Jan 89

[Text] Moscow January 30 TASS—The flight control centre reports:

The automatic interplanetary station Phobos which covered over 470 million km in 200 flight days, has been changed over to the orbit of Mars' artificial satellite.

The station had its trajectory corrected on January 23 for it to approach Mars, and then it changed over to a trajectory 800 km from the surface of the planet. In accordance with the flight programme, the station's braking rockets fired at 3:55 pm on January 29. The reverse-thrust operation was done by the board control system which uses a previously elaborated programme and data of operational ballistic calculations. The manoeuvre put the station in an elliptical orbit, close to the calculated one, with the following parameters:

—the maximum distance from the surface of Mars (in apogee)—79,750 km,
—the minimum distance from the surface of Mars (in perigee)—850 km,
—the orbit's inclination to the Martian equator—1 degree,
—the period of revolution around the planet—76.5 hours.

Comprehensive exploration of the surface, atmosphere, plasma and magnetic envelopes of the planet will be carried out from aboard the station in the course of its flight in that orbit. Sophisticated navigational measurements of the relative movement of the Martian natural and artificial satelites will later be made and a number of active manoeuvers will be carried out to ensure the station's gradual approach to Phobos.

Research Prospects Noted

LD2901172189 Moscow TASS in English 1654 GMT 29 Jan 89

[Text] Moscow January 29 TASS—The inter-planetary automatic station Phobos, which was launched from the Baykonur cosmodrome on July 12, 1988, became an artificial satellite of Mars at 3:55 p.m. today. It covered a distance of 470 million kilometres.

TASS scientific news analyst Aleksandr Romanov, now at the Phobos station mission control centre, has had this to say:

"For the first time in mankind's history the planet of Mars has acquired one more satellite. The automatic station, put in a near-Mars orbit, and then its planned landing on the Phobos satellite will bring mankind closer to unravelling mysteries of the planet: either Phobos, a Martian satellite, is a creation of nature or it was created by reasonable creatures once inhabiting Mars".

"Great scientist and designer Sergey Korolev was the first to dare to reach out to Mars to unravel its mysteries. Automatic interplanetary station, created under his direction, reached the moon in 1959. In 1961, Korolev-designed spaceship put into space mankind's first cosmonaut Yuriy Gagarin. In 1962 the Mars-1 station, also designed by Korolev, was launched towards the faraway planet of Mars. Having flown at a small distance from the planet, the Soviet station Mars opened the way to the red planet for other Soviet and American automatic flight vehicles".

"And now the interplanetary automatic station Phobos is in flight. Its having been put into orbit around Mars is perhaps not the most important part of the whole program", said one of the Mars-Phobos program directors, Professor Nikolay Ivanov. "Within a long period of time the automatic station will change a number of near-Martian orbits in the zone of Phobos. The automatic station will finally lower down to a height of 50 kilometres and then hang 50 metres from the surface of Mars' satellite. For 25 minutes the equipment aboard the station will be able to carry out radiolocation and television panorama survey of Phobos, to make analysis of soil element and isotope composition, determine the structure of rock and relief of the satellite, etc".

"One will have to wait for over a month for the most important concluding stage of the durable autonomous laboratory's landing on the Phobos surface", Professor Ivanov said.

"Chief designer of the Soviet Energiya rocket Boris Gubanov believes that apart from purely scientific importance the Phobos program, exploring Mars and

one of its satellites, is of great significance since the program is laying the way to Mars for man. The carrier rocket Energiya which recently stood tests after modernisation can lift into space a weight much greater than 100 tons. This gives one ground to believe that it will be able to launch a multi-ton manned spaceship towards Mars. I think that one should wait not so many years for that to come true", he said.

UDC 531.352

Evolution of Motion of Viscoelastic Planet With Retrograde Rotation in Gravitational Field of Two Point Masses

18660235 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 3, May-Jun 88 (manuscript received 15 Oct 86) pp 358-365

[Article by K. M. Lebedev]

[Abstract] Nonlinear resonance phenomena in the solar system, including commensurability between the axial and orbital motions of the planets, as well as resonance in the motion of Venus, are attracting increasing attention. As a contribution to such research a study was made of evolution of the translational-rotational motion of a viscoelastic planet moving in the field of two gravitating points. The problem is solved in the following formulation. The motion of a triaxial planet, close in configuration to a sphere, is in the field of two gravitating points with the masses m_1 and m_2 (m_1 is much greater than m_2) under the condition that the point m_2 revolves about the point m_1 in a circular Keplerian orbit with the radius b and with a stipulated mean motion. The center of inertia of the planet, having the mass m and the mean radius r_0, moves along a perturbed Keplerian ellipse with a focus at the point m_1. The planetary motion is assumed to occur in the orbital plane of the point m_2 and the kinetic moment of characteristic planetary rotation at all times is orthogonal to its orbital plane. This is used as a basis for constructing a model of the Sun-Venus-Earth system. An averaging scheme is used in investigating resonance modes in two-frequency oscillatory systems. Figures 2; references: 8 Russian.

UDC 550.81:523.42

Venusian Atmosphere in North Polar Region

18660009 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26, No 4, Jul-Aug 88 (manuscript received 24 Jun 87) pp 584-590

[Article by S. S. Matyugov, V. N. Gubenko, O. I. Yakovlev, G. D.Yakovleva and I. R. Vaganov]

[Abstract] This is a continuation of a series of articles on research on the Venusian atmosphere (O. A. Yakovlev, et al., KOSMICHEKIYE ISSLEDOVANIYA, Vol 25, No 2, p 275, 1987; Vol 25, No 2, p 267, 1987; Vol 25, No 2, p 258, 1987). The article describes the state of the atmosphere in the Venusian north polar region in the altitude range 40-90 km at latitudes from 63.7 to 78.9°, with solar zenith angles 76.6-108°. The study was made for 16 regions in the northern hemisphere for the period 12 October 1983 to 6 September 1984 using data from the "Venera-15" and "Venera-16" satellites. These results supplemented available data on the north polar region and make it possible to determine the temporal variability of state of the atmosphere. Comparison of data for the northern and southern hemispheres became possible. A series of vertical temperature profiles was constructed (Figures 1-3 in text, showing the dependence of temperature, pressure and density on altitude) and is discussed in detail. The overwhelming majority of the temperature profiles in the north polar region exhibit a temperature inversion above the tropopause. This inversional character of the profiles is stable for about 10 months. Figures 3; references 7: 4 Russian, 3 Western.

Psychologists Profile Ideal Mars Space Crew

LD0101101889 Moscow World Service in English 0900 GMT 1 Jan 89

[Text] Soviet psychologists recommend that a crew for a space mission sent to Mars should be all male and limited to six or eight members. The best age is from 35 to 45 years.

This is the conclusion drawn from the experience of long-term orbital flights, including the recent year-long mission of Vladimir Titov and Musa Manarov aboard the Mir station.

Specialists hope to launch the first ever interplanetary expedition in the year 2015. The Soviet Union is for making it an international mission.

Medical and Biological Support for a Manned Expedition to Mars

18660014 Moscow ZEMLYA I VSELENNAYA in Russian No 5, Sep-Oct 88 pp 15-20

[Article by Doctor of Medical Sciences O. G. Gazenko, Doctor of Medical Sciences A. I. Grigoryev, and Ye. A. Ilin, Institute of Medical and Biological Problems, USSR Ministry of Health; first paragraph appears in boldface in source]

[Text] **Soviet space medicine and biology has achieved outstanding results in terms of support for prolonged manned flights. All the existing experience in this field serves as good groundwork for setting up a manned expedition to Mars, participation in which General Secretary of the Central Committee of the CPSU M. S. Gorbachev suggested to the American side in the person of U.S. President R. Reagan.**

Flight to other planets is something that has long been one of the most exciting problems stirring mankind. But much of what for centuries seemed impossible, what even yesterday was only a dream, is becoming a reality right before our eyes. The entire history of the development of the space program confirms the correctness of the words of our great countryman K. E. Tsiolkovskiy, who said, "What is impossible today will become possible tomorrow."

And today's projects for manned expeditions to Mars, which also seem fantastic from time to time, have a very real foundation beneath them. This pertains primarily to the huge successes in scientific and technical progress as a whole and in the space program in particular. Everything that has been achieved on prolonged manned space flights—where the preeminence of domestic science, the excellent work of space equipment, and the state of health of cosmonauts in the course of such expeditions and after their completion are unquestionable—certainly inspires optimism about the possibility of yet longer stints in space and success in overcoming the barriers of weightlessness along the way.

Today, the range of opinions on the possible schedules for performing the martian expedition is rather broad—from the most optimistic, in which this manned flight could be done as early as sometime before the end of this century, to the most cautious, which means schedules in the more distant future. Which is quite understandable. Forecasting, after all, is a rather complex matter. One thing is for sure—the expedition will be another step into the unknown. And each such step must be made on the basis of already accumulated knowledge, correct evaluation of all previous experience, and balanced analysis of actual conditions and possibilities. Especially when man, his health, and his safety are involved. This very approach enabled Yu. Gagarin to open the way to space, A. Leonov to step out into open space, and N. Armstrong to set foot on the Moon.

Of course, the experience acquired in years past in medical and biological support of manned space flight is a good stockpile for future, confident steps along the road in space. However, a great deal more needs to be done to get really close to solving the problem of a manned expedition to Mars.

One of the principal medical and biological problems of the martian expedition will, of necessity, be the problem of habitability, that is, the full biological value of the living environment in the ship and its adequacy for meeting the long-term biological needs of man.

This aspect of habitability has yet to become a subject of scientific analysis—not to mention experimental research—although we expressed several initial ideas as early as the 1970s. The scientific inevitability of such a formulation of the problem, when man is separated from Earth for a long time, is intuitively understood by medical people and biologists and can be logically inferred from the fundamental principle of natural science on the harmony of organism and environment.

Of course, we are speaking here of the innate natural environment of the biosphere of the Earth, where, in the process of man's long evolution, his innate long-term needs have also formed. That itself is, for space medicine and ecology, the standard of man's living environment, and the longer he is separated from Earth conditions, the closer the actual artificial living environment aboard spacecraft and space stations must be to that standard. That is the kind of approach needed in the planning of a manned flight to Mars.

Until now, an ecological concept for the living environment of the cosmonaut has rarely been used in the field of medical support for space flight. That role was occupied by the concept of life-support systems, with its, as it were, "quartermaster" logic: life-support systems should do such things as supply man with oxygen, water, and

food and remove carbon dioxide. But with the broadening prospects of interplanetary space programs, the question is no longer about "supply" or "provision," but about the comprehensive production of a biologically genuine living environment for man that approximates the terrestrial standard.

Thus, the transition from flights in near-Earth orbit to interplanetary flights and planetary bases requires a qualitatively new approach to the understanding of the conditions of man's long-term existence in an artificial environment and of the need to develop a theory of the living environment in a broader, ecological scheme. It is likely that effecting such new thinking will turn out to be one of the most important tasks of space hygiene and human ecology. But that is the science of the future.

With regard to the martian expedition, we must start with means that are realistic for the near future, means that can provide a natural living environment for man. There is only one way to create, away from Earth, a functional analog of the natural environment—and that is to use natural biological mechanisms in which, through the combined action of plants, animals, and microorganisms, the Earth's natural environment comes about, biogenic in its origin.

Such an objective can be reached through the creation of closed ecological systems, with man a necessary functional component of them. A biologically genuine living environment for man in these systems will be produced through the same biological mechanisms that are in nature, regardless of the incompleteness of the existing body of knowledge about the mechanisms themselves as well as the biogenic components of the natural environment.

We have already created and studied various laboratory models of such man-included systems that are based on the activity of single-cell algae, higher plants, and microorganisms. Not only is air and water recycled, but part of the vegetable food is reproduced. In such models, up to 80-90 percent of the substances man needs is regenerated. Moreover, the possibility of using certain animals to produce some of the animal products is being studied.

For flights to Mars, it is hardly sensible to propose a full-scale biological system that is capable of providing for all of man's needs. On such a long flight, there is no need for such a system, and it would hardly be efficient—it would take up a great deal of room and would use a lot of energy.

However, nor can a physical-chemical regenerating system, for which specific technologies for producing oxygen and water from the products of human activity are developed, be proposed. At this point, it is the most efficient in terms of weight, size, and energy features, but such a system cannot create a biologically genuine living environment for man, which will be very important on the rather lengthy expedition to Mars.

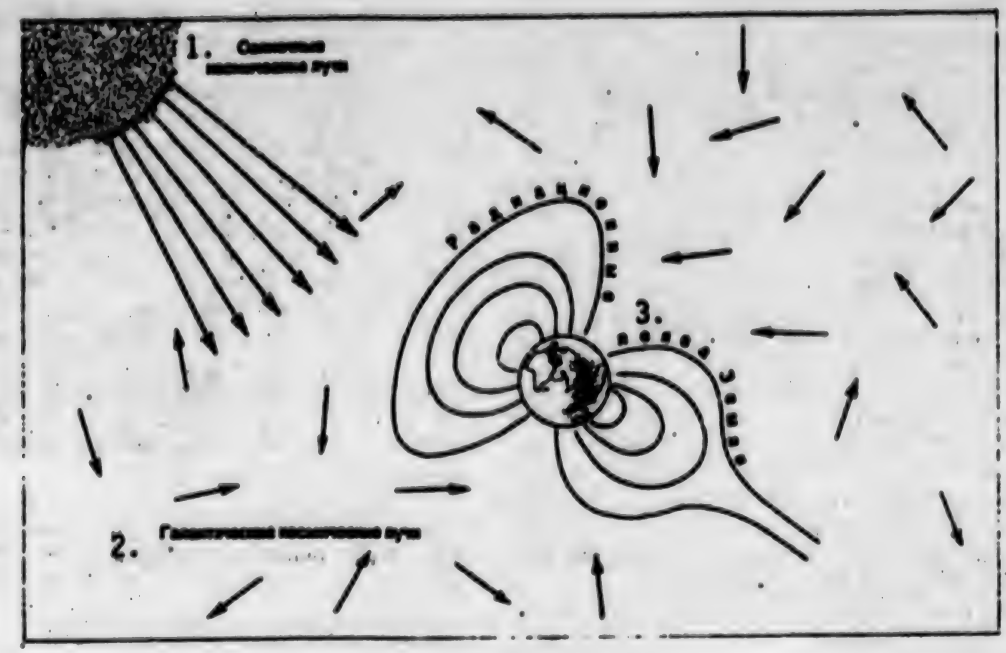
The most promising here, in our view, are combined systems that include both physical-chemical processes and biological processes. The inclusion of photosynthesizing organisms and certain animals in the life-support system will make it possible to reproduce some natural plant and animal food and bring the cosmonaut's living environment close to actual natural conditions, that is, make it more genuine in a biological sense. For that, the share of basic functions that the biological system has in the overall complex of the life-support system must be rather large, although, of course, it will be limited by the weight, space, and energy constraints of the manned vehicle. At any rate, for a biological life-support system to play a tangible role in producing a biogenic environment, photosynthetic processes must be capable of regenerating air at a rate of no less than 30-40 percent of the nominal. Of course, those are just preliminary ideas, subject to experimental confirmation.

The proposed biological system may consist of single-cell algae, higher plants, and certain animals, such as poultry or fish.

In addition to its role in regenerating the air in the ship, such a system will perform other important functions that optimize the ship's environment: it will purify the air of water-soluble volatile substances, stabilize the population size and species content of the microflora aboard the ship with the antagonistic microflora that accompany algae, optimize the space ion composition of the air, and hold down the overall amount of dust in the air and the number of heavy aerosol particles.

Including a biological system in the overall complex of the life-support system will also help to resolve certain questions that arise in connection with the possible effects of man staying for lengthy periods in a totally artificial, abiogenic living environment.

From the standpoint of radiation safety, the primary feature of man's flight to Mars lies in the absence of the protection that the Earth's geomagnetic field provides. Spacecraft in near-Earth orbit receive less of a dose of galactic and solar cosmic radiation, and as long as space flight continues to be below the Earth's radiation belts, the problems that arise will not be too complex. But with interplanetary flight, galactic cosmic radiation—which consists of nuclei of chemical elements that have relativistic velocity—acquires a great deal of importance. Based on certain experiments, researchers suggest that over a two-year stint in space, a cosmonaut can expect to lose a comparatively high number of nerve cells in the cerebral cortex as a result of exposure to relativistic atomic nuclei. At least in a range that is comparable to losses in the natural aging process. However, from the biological standpoint, the topography of the track, or trace, of heavy particles is significant, especially if its route is through a cluster nerve cells that form any sort of vitally important center in the brain. That means that the future development of interplanetary flight depends, to a large extent, on solving this problem.



Sources of radiation hazards in space
Key: 1. solar cosmic rays—2. galactic cosmic rays—3. Earth's radiation belts

Since the dose of galactic cosmic radiation depends on the phase of the solar activity cycle, and shields (of reasonable thickness) to protect against such radiation are ineffective, it is advisable to perform flights during the solar maximum, when there is a minimal flux of galactic cosmic radiation. During that period we also observe the fewest phosphenes, which are caused by particles of galactic cosmic radiation in the eyes of the cosmonaut.

In order to lower the radiation hazards of solar flares (which occur most often during the solar maximum) to acceptable levels, the space station must have a radiation shelter, within acceptable weight constraints, that can reliably protect against solar cosmic rays and an independent, extremely reliable radiation-monitoring and hazard-forecast system that will enable the cosmonauts to evacuate to the shelter in plenty of time. The methodical outfitting of such a system and its development constitute a complex scientific and technical problem, but solving it is much more realistic than trying to develop a shield against galactic cosmic radiation.

Other effective means of radiation safety on a flight to Mars may include pharmacological prophylaxis, strict monitoring and regulation of radiation dose for each crew member, and monitoring of the condition of the cosmonauts with the appropriate examination systems, as well as the presence of a physician-cosmonaut and, finally, the use of additional means of local shielding when necessary.

In spite of their disagreements, specialists concur that the present level of development of equipment and technical efforts give hope to the positive solution of the problem of radiation safety on a martian expedition.

Solution of the psychological aspects—the individual's mental readiness to complete a flight that is unavoidably associated with a definite degree of risk — will also play an important role in carrying out an expedition to Mars. Of great import, of course, will be any sort of prior experience and an awareness of the crucial situations an individual may encounter on the flight to Mars. For that reason, the step-by-step preparation for such a flight is an essential condition: beginning with unmanned flights to Mars, landing them on the planet, returning them to Earth, and so forth. An extremely important juncture will be reached when there is absolute confidence in the vehicle that will be used for the flight and a certainty that none of its systems will fail or that all repairs can be done along the way.

The number of crew members will probably be determined primarily by the design features of the technical systems used to carry out the flight and by the scientific mission both in flight and on the surface of Mars. Psychologists feel that the crew should consist of males only and should not exceed 6-8 individuals. The crew should include mature individuals, aged 35-45, who are specialists with professional experience and life experience. Space flight experience is a must. It is not necessary that such experience involve flights whose duration is comparable to that of the martian expedition, but it is

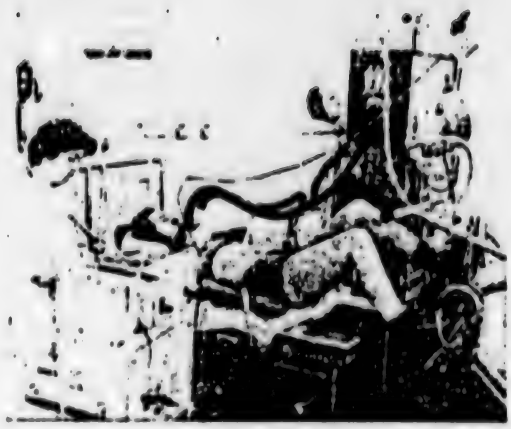
desirable that the individuals have under their belt experience involving flights of at least six months in duration, which enables them to adapt themselves to life aboard a spacecraft, with all its attendant features. The crew must include a highly skilled physician who is well-trained in treatment, surgery, psychotherapy, and psychology.

A manned flight to Mars requires the solution of a number of physiological problems associated with long stints in weightlessness. Over the years, space medicine has gathered no small amount of knowledge on the effects that weightlessness has on the human body. More than 200 individuals have flown in space already, for varying durations. Five Soviet cosmonauts have stood space watch for more than 200 days each, and Yuriy Romanenko has come very close to spending an uninterrupted year in space. Several cosmonauts have assembled rather impressive figures in terms of number of flights, while Yuriy Romanenko has spent a total of 430 days in space. Medical research and experiments play a big role in current flights, and, consequently, it can be said that the foundation for continued advance along the road in space is being laid well.

Today we know a great deal about the responses of the body to weightlessness, and, by and large, we understand the mechanisms of their appearance. It has been established, specifically, that man is capable of adapting satisfactorily to long-term exposure to weightlessness and, upon completion of a long flight, to Earth's gravity. We can rather clearly and completely picture the general course of the process of adaptation to weightlessness, specific phases of the process, and the state of the various physiological systems that are involved at the various stages of adaptation.

The system created by Soviet specialists to prevent adverse effects of weightlessness on the body enables cosmonauts to withstand weightlessness quite successfully, even on prolonged flights, and to be prepared to meet Earth's gravity. Of course, the potential exists for improving this system of prevention, and work is being done in that area.

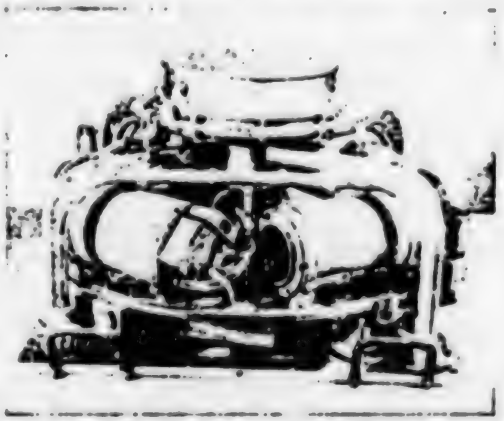
Let us briefly list the changes in the body on which we must focus our undivided attention when it comes to a future manned flight to Mars. First of all, there are changes in the locomotor system. As of yet, even on the longest flights, we have, fortunately, observed no substantial changes in the locomotor system, thanks to preventive equipment. Moreover, with an efficient approach to the use of the preventive complex, such changes have been less pronounced in some cosmonauts after long flights than after short flights. A lengthy stay in weightlessness causes specific changes in the body's metabolic processes. In particular, decalcification occurs—that is, a loss of calcium—primarily in the skeleton. Although we have managed to deal successfully with such changes via corrective means, we must not forget that they involve flights of considerably shorter



Study of the activity of the human cardiovascular and respiratory systems during the exercise on a bicycle ergometer. Photo by A. Dotsenko

duration than the flight to Mars will be. Changes in immune response have also been observed on long flights, which could raise the chance of illness if no effective measures are taken. Far from everything is clear about the blood system's responses to long-term weightlessness.

Now a few words on artificial gravity as a preventive measure. At one of the meetings of the Moscow International Forum, which was devoted to the 30th anniversary of the space age, cosmonauts and astronauts spoke out in favor of a flight to Mars in weightlessness, without a centrifuge. The medical people, however, favor the creation of artificial gravity aboard the spacecraft. Science must gather the necessary material to provide a balanced answer. For the time being, there are no convincing materials in favor of either solution.



The centrifuge for creating artificial gravity aboard the Cosmos-936 biosatellite (1979). A postflight study of a group of rats indicated that artificial gravity prevented, to a large extent, adverse changes in the animals' bodies induced by weightlessness.

On the whole, the continuing accumulation of medical and biological information must lead us not only to a more thorough evaluation of the role of man in space, but also to a fuller understanding of the possible complications and difficulties that man may encounter on future flights. Essentially, that means the continuous improvement of the safety aspects of flight through the growth of the reliability of space equipment as well as the reliability of man himself.

This article, of course, does not cover all the problems involved in the medical and biological support of a manned expedition to Mars. It is only an attempt, from the standpoint of today's knowledge, to present just some of principal problems that remain to be solved on the road of continued development of outer space. Without a doubt, as we accumulate more knowledge, our notions on these problems and the possibilities of solving them will change.

Unexpected things await us ahead. Such is the logic of scientific investigation, as it moves ahead on the basis of earlier findings and removes the barriers of the unknown, and scientists are stepping into uncharted regions and are encountering new and, as a rule, still more difficult problems.

Now, when mankind is at the threshold of the twenty-first century, amid the various trends of its development, that which is ancient and forever youthful is still being singled out and infused with new meaning—the conquest of space. Mankind has set out on the stellar highway, and there is no stopping that motion. The flight to Mars represents a very complex task. It requires hugh expense and the creation and mastering of the most complex equipment. The uniting of nations in behalf of the peaceful development of space is a dramatic goal that justifies the immense efforts to send an expedition to Mars.

Foreign Broadcast Information Service (FBIS) and Joint Publications Research Service (JPRS) publications contain political, economic, military, and sociological news, commentary, and other information, as well as scientific and technical data and reports. All information has been obtained from foreign radio and television broadcasts, news agency transmissions, newspapers, books, and periodicals. Items generally are processed from the first or best available source; it should not be inferred that they have been disseminated only in the medium, in the language, or to the area indicated. Items from foreign language sources are translated; those from English-language sources are transcribed, with personal and place names rendered in accordance with FBIS transliteration style.

Headlines, editorial reports, and material enclosed in brackets [ ] are supplied by FBIS/JPRS. Processing indicators such as [Text] or [Excerpts] in the first line of each item indicate how the information was processed from the original. Unfamiliar names rendered phonetically are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear from the original source but have been supplied as appropriate to the context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by the source. Passages in boldface or italics are as published.

SUBSCRIPTION/PROCUREMENT INFORMATION

The FBIS DAILY REPORT contains current news and information and is published Monday through Friday in eight volumes: China, East Europe, Soviet Union, East Asia, Near East & South Asia, Sub-Saharan Africa, Latin America, and West Europe. Supplements to the DAILY REPORTs may also be available periodically and will be distributed to regular DAILY REPORT subscribers. JPRS publications, which include approximately 50 regional, worldwide, and topical reports, generally contain less time-sensitive information and are published periodically.

Current DAILY REPORTs and JPRS publications are listed in *Government Reports Announcements* issued semimonthly by the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161 and the *Monthly Catalog of U.S. Government Publications* issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The public may subscribe to either hardcover or microfiche versions of the DAILY REPORTs and JPRS publications through NTIS at the above address or by calling (703) 487-4630. Subscription rates will be provided by NTIS upon request. Subscriptions are available outside the United States from NTIS or appointed foreign dealers. New subscribers should expect a 30-day delay in receipt of the first issue.

U.S. Government offices may obtain subscriptions to the DAILY REPORTs or JPRS publications (hardcover or microfiche) at no charge through their sponsoring organizations. For additional information or assistance, call FBIS, (202) 338-6735,or write to P.O. Box 2604, Washington, D.C. 20013. Department of Defense consumers are required to submit requests through appropriate command validation channels to DIA, RTS-2C, Washington, D.C. 20301. (Telephone: (202) 373-3771, Autovon: 243-3771.)

Back issues or single copies of the DAILY REPORTs and JPRS publications are not available. Both the DAILY REPORTs and the JPRS publications are on file for public reference at the Library of Congress and at many Federal Depository Libraries. Reference copies may also be seen at many public and university libraries throughout the United States.

END OF FICHE DATE FILMED

14 MARCH 89